DUNLOP IN WAR AND PEACE

The Chairman of Dunlop, Sir J. George Beharrell, D.S.O., sending off a pigeon on the Dunlop pigeon post.

DUNLOP
IN WAR
AND PEACE

by

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with a Preface by

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Prepare war, wake up the mighty men, let all the men of war draw near; let them come up: Beat your plowshares into swords, and your pruninghooks into spears: let the weak say, I am strong.

—Joel iii, 9-10.

Falces conflantur in enses: Scythes forged into swords.

—Gibbon's regimental motto for the South Hampshire Grenadiers.

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By SIR GEORGE BEHARRELL

THE history and achievements of Dunlop in the past made it natural that when Britain faced the crisis of her survival in 1939, the nation would expect Dunlop to be prepared. That expectation proved justified. With every month, starting long before September 1939, the men and women whose splendid teamwork constitutes the Dunlop organization, increased their vital contribution to far off final victory.

The second World War, both on land and in the air was fought on rubber tyres. This was a war in which speed counted far more than static strengths, and it was rubber alone that made possible the mechanization of the armies and the air forces. When the long-awaited moment to deliver the knock-out blow to the enemy finally came, it was the armies on rubber tyres that raced across France, Holland, Belgium and Italy and brought the conflict to an end.

In this struggle to save civilization, which only succeeded by a narrow margin, British arms stood first and foremost, for a while entirely alone and always in the forefront. And it was to help British arms in the field and in the air, and to protect the training armies and the civilian population at home, that Dunlop devoted its all—in men and woman power, in inventive genius, in its technical and manufacturing developments, during every hour that the conflict lasted.

Dunlop is so vast and its manufacturing processes are necessarily so far flung over such a diversity of units that many an individual in the organization could hardly realize how immensely important to the whole war effort was his or her personal contribution. This book is an attempt to present a unified picture of the total Dunlop job in the war, first for the men and women whose efforts made the work so abundantly successful and then for a larger public.

The picture is splendid and encouraging. Splendid because it records magnificent accomplishment by the thousands working towards the single goal of victory: encouraging because it proves that what could be done to save the nation during the hazard of war when bombs impeded production, raw materials were scarce or unobtainable and labour hard to find, can, and with infinitely better conditions for production, should, carry the nation back to prosperity and its people to a standard of living hitherto unknown.

This must necessarily be a record of material things. Even as such it is unique and inspiring. War, however, is won as much by spiritual forces as by bullets. The patriotism, self-sacrifice and willingness to work to the point of exhaustion, which were typical of every section of Dunlop's vast organization, were as much a part of the final victory as the tyres, wheels, balloons, dinghies, uniforms, shoes and innumerable other Dunlop products—great and small—which were the visible and material result of an unparalleled spiritual effort.

INTRODUCTORY NOTE

IT may seem almost impertinent that a profoundly untechnical outsider should presume to describe and record Dunlop's War Effort. Against this defect of ignorance it may be urged that what's strange, strikes sharp; while the expert is apt to write with an eye on fellow experts, forgetting that workers intimately qualified in their own Department may yet be comparatively ignorant of other processes but a few yards distant in the same great Public Service. (So, in discussion on foreign politics, an authority in Balkan affairs will sometimes reveal a surprising ignorance of the Palestine problem.) All I can bring to bear is an almost nosy inquisitiveness, coupled with deep appreciation of what that has revealed: but I do claim to have explained nothing that I have not first made clear to myself by nagging the authorities for definitions of the (all too numerous!) terms, obvious to them, which at first meant nothing to me. If such minor qualifications prove insufficient, then, as Othello with Desdemona, I must refer the court back to Dunlop, who "had eyes, and chose me."

Walking round these giant factories at Birmingham, Liverpool, Manchester or Edmonton was an inspiration, though often a bewilderment also. The overmastering din, during which however adepts seemed to be able to carry on conversations without difficulty or shouting—yet the relief from silence demanded in the quieter rooms and obtained by the (almost overwhelming) all-in radio. I learnt that this latter amenity is far more popular with women than with men, who make no secret of disliking it. Faces were concentrated, even to tenseness, but often smiling, rarely bored and never sulky. Yet the work was in varying degrees arduous, monotonous and sometimes irritating. Meals were punctiliously confined to stated hours—in sharp contrast to the almost non-stop procession of elevenses from nine a.m. to six p.m. in many a Government Department.

There was the 40-year old machine, anticipating in its kind anything yet in use across the Atlantic, which had evoked the astonished admiration of American experts; and the giant bomber tyres, 5 feet 6 inches high, into which you could easily put two grown men, and from which I had seen the flames flash as they landed on the parched sunbeaten dromes of Delhi and Khartum. There was the Cyclopean vulcanizer; and those Leviathans—the steel tunnels along which masses of metal are cleansed of rust by a roaring blast of sand. One saw conveyor belts being made in lengths of about a furlong and destined to carry commodities ranging from pig-iron to pork-pies. Stacked in another hangar were 100-lb. packages of synthetic rubber from the United States. Ebonite acid-carrying jugs, bowls for gathering tea from plantation bushes, the common (though alas now less frequent) vulcanized screw beerstopper and, produced for Nobels, rubber lining to prevent the explosion of guncotton

tanks—nothing surprised, after a few hours wandering in Dunlopia. The merciless electric scissors which shear effortlessly through a dozen thicknesses of jacketings or trouserings and the 33 operations which go to the making of a Service greatcoat; the chance fact (sticking in one's memory) that for waterproofing, synthetic rubber cannot compare with natural—and the excellent hot luncheon served to operatives for eightpence. Tyres which to the eye of ignorance look well enough, have no secrets for the head of the remoulding section, who probes their defects with the same swift uncanny diagnosis as did Kim's Healer of Sick Pearls.

For the voyager during war, the universality of Dunlop tends on further acquaintance to become almost an obsession. Dunlop factories are scattered across the continents from Cork to Calcutta; Dunlop representatives from Cairo to the Cape. In Jedda, far down the Red Sea, crowds of Arabs had assembled to greet their venerable sovereign, King Ibn Saud, returning from his first journey abroad—to meet Mr. Churchill and President Roosevelt in Egypt. The town was brilliantly decorated with official, semi-official and unofficial standards. I asked an Arab who was watching the procession from the same roof as myself what was the meaning of a small yellow pennon fluttering with others in the morning breeze. "That," he replied, "is, naturally, the flag of Dunlop, which is flown with the other Consular flags."

Later last year—and in some ways most significant of all these impressions—was a bicycle I found (during a lecture-tour for the Admiralty) leaning up against a door in ruined Hamburg. It was a British machine bought in 1939, and ridden through the war without the possibility—or the necessity—of replacing its Dunlop tyres.

RONALD STORRS
March, 1946.

SECTION I—PRELIMINARY

CHAPTER I

RUBBER

THERE are few substances, apart from wood, iron and paper, whose existences and uses are more generally taken for granted to-day than rubber. For two generations past you would not have found one civilized man, woman or child who did not assume india-rubber (as I can well remember its being called) for the vital as well as the ordinary necessities of everyday life. Yet it is one of the latest as well as the most revolutionary industrial products. Noah used wood, Homer knew iron and Shakespeare gunpowder, but any substance with the properties of rubber was unknown and unimagined, so that well into the ninteeenth century Napoleon was still drenched to the skin and bumped and banged on his journeys backwards and forwards across Europe for lack of this now universal convenience. Little practical use for rubber was invented for nearly three and a half centuries after its discovery in the days of Columbus, until 1839, when the secret of vulcanization, or hardening by sulphur, was ironically revealed to a harassed inventor who was trying to evade a curtain lecture from his wife. In the early stages therefore crude rubber was as useless as pure gold; both must be compounded or alloyed before they can be directed to the service of mankind.[1]

And even now, after the brain of civilization has studied and worked on rubber for more than a century, what do we really know of the essence, the composition, of the mysterious substance? Botanists will tell us that it is tapped as latex—a juice and not a sap—from between the outer and inner bark of the tree *Hevea brasiliensis*, which grows wild by the Amazon; that the Indians there called it Cahuchu or Cauchu—Weeping Wood—which the French, with characteristic precision, adopted as *Caoutchouc*, and the modern Arab, for his tyre, as *al-Kawich*. By the addition of acetic acid latex becomes a dough-like mass which can be easily rolled.

Why is it called rubber? There is a legend that the scientist Priestley named it thus because he found it would rub out pencil marks. But if you are interested in etymology, one of the most rewarding of indoor sports, try hounding down the derivation of rubber in *The Oxford English Dictionary*. Even here the scent is poor, and you will never kill: "Rubber—

[1] Since 1915 vulcanization, which originally took 100 minutes, now takes no more than 15: a saving in cost equal to a quarter of the whole labour cost in a rubber factory.

Elliptical for India-Rubber." You gallop back to volume One for "India Rubber, India-Rubber," relieved to find that you can't go wrong with the spelling, gratified to learn that the word is as old as 1799 but baffled to find yourself referred back, with "Caoutchouc, *q.v.*, in later use shortened to *rubber*." And it is in "Caoutchouc" that your quarry finally escapes you, with "India-rubber or Gum Elastic," and you realize that, for the original derivation of the word rubber as applied to this material

"that is all
Ye know on earth, and all ye need to know."

Chemists will tell us that it is a hydro-carbon of which the structural unit is the isoprene molecule, made up of 5 parts of carbon and 8 of hydrogen—simple enough so far but the formula is an empirical one $(C_5H_8)X$ and the value of X is still unknown. Rubber is truly a baffling material. The most elastic and resilient in the world: yielding, but returning to position; flexible, but incompressible, for, press it as you may in one direction, it will always occupy the same total space, so that steel moulds or hydraulic rams will break before rubber gives way. It can be extended to eight times its natural length without breaking, and then resume its original form.

It has been observed that "the price movements of rubber are as erratic and resilient as rubber itself, and that it has been as difficult to control politically as physically." Its price fluctuations from about 1875 until the present time look like a fever chart. Vast fortunes have been floated—and sunk—by rubber. In 1920 the price fell from 2s. 10d. to 9d.; when paper fortunes, made in rubber, faded again into paper. Further, that every nation which has sought to extract an excessive profit from rubber has found that the control of the market—and of the material—has slipped from its grasp.

Since the invention of vulcanization in 1839, rubber has been the most dramatic—almost melodramatic—of the world's natural products. It has played its part—an ever more important one—in politics, economics, geography, in commercial and tariff wars, and finally in the aggressive Imperialist war of the Japanese. Industrialists whose chief raw material it has been, have had to take long chances in accumulating huge reserves, sometimes leading to tremendous losses; while Britain, the United States and the other Allied Nations in the second World War had to endure bitter sacrifices in lives and in national wealth through the sudden and unexpected loss of their normal sources of supply.

Rubber as used in the modern world owes more to Britain than to any other nation. From 1839 down to 1876, and for a considerably longer period, practically all commercial rubber came from Brazil. It was regarded by that country as a natural monopoly and guarded as such. The rubber tree was indigenous to the Brazilian jungles of the upper Amazon river, but its collection was uneconomic and often attended

with atrocious inhuman cruelty which it has been left to the age of Hitler to equal.

This crude rubber reached the markets of the world after many thousands of miles of land, river and ocean travel. It was ungraded, mixed with impurities, sticks, and stones, and thus was difficult to handle. Moreover, the supply was uncertain and prices rose swiftly and fantastically; but shrewd business men realized that an enormous market would develop for a wide variety of articles made of rubber as soon as the price and supplies became reasonable and stable.

The great turning point which was to raise rubber from haphazard jungle plunder to a cultivated and rapidly improving product high in the commercial economy of the world, came in 1876. In that year Sir Henry Wickham, an Englishman whose name should be forever honoured—and not only by Britain—conveyed 70,000 seeds of the Hevea rubber tree out of the Amazon basin. He brought them to Kew Gardens and set them out there. A fair proportion of the seeds germinated, and 2,700 slips were sent to Ceylon and from there seedlings were sent subsequently to Malaya. Here they were destined to found a new industry to help the struggling colonial planters with another crop in addition to coffee, coconuts and the few others already grown there.

This was the foundation of the tremendous plantation rubber industry of to-day. At the outset it grew with what now seems incredible slowness. However, the mills of economics began their inexorable grinding in favour of plantation rubber; expedited by the speculators who controlled the Brazilian supplies, which as late as 1906 comprised 90 per cent of the world's supply. They ran the price to unconscionable heights and in 1910 actually succeeded in forcing rubber, of which there was an undoubted world shortage, up to 12s. 9d. a pound.

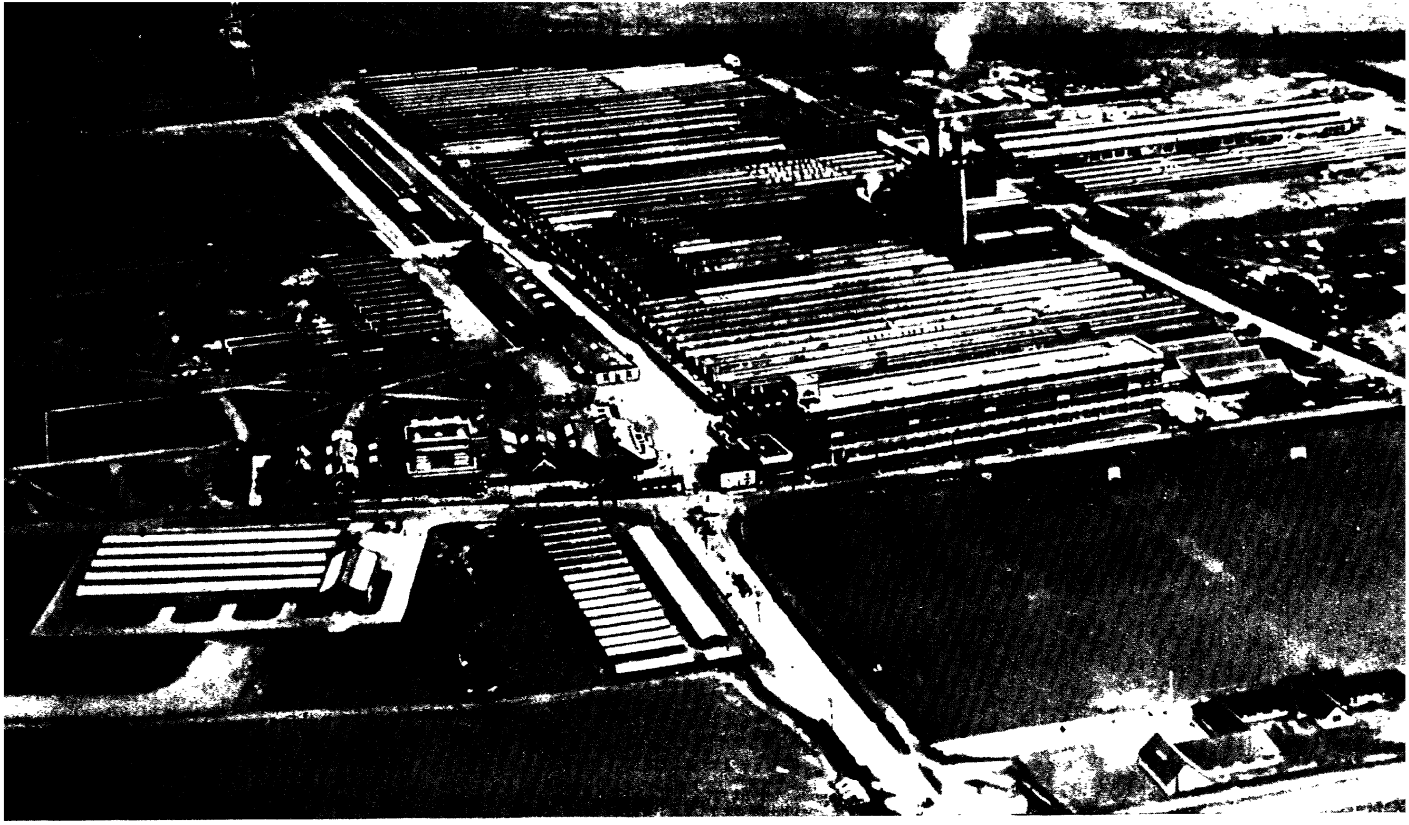
Here was the signal for starting the great British plantations in Malaya. The Brazilian rubber speculators had cut their own throats; but in retrospect it is clear that Brazil could never have supplied the demand which the modern motor car, undreamed of when Henry Wickham shipped his seeds home, rapidly brought into being. "From 1913 Brazil and wild rubber were out, and the East and plantation rubber were in." What the plantation industry owed to Henry Wickham for its birth, it owed to the motor industry in its giant maturity.

Therefore it is evident that the world, whose whole economy and standard of living is to-day based on a rubber cushion, owes a great debt of gratitude to the pioneer British investors who were willing to venture millions in an industry whose future could not be foreseen. The risk of synthetic or artificial rubber could obviously not have been anticipated then; but there were other risks such as that of rubber tree diseases which have, in fact, wiped out later attempts to grow plantation rubber in some other parts of the world. Up to the outbreak of the second German World War in 1939 by far the largest use of rubber was for tyres

for motor vehicles of widely varying types. Various exclusion and regulation schemes had broken down and the world rubber market was open to all, although the great bulk of rubber came from Malaya, the Netherlands East Indies, Sumatra, India and Siam; all, it may be observed, regions within 10 degrees of the equator. Two countries which had no natural rubber resources under direct national control and which were aiming at self-sufficiency—the hideously named "autarky"—had begun to experiment with substitutes. Germany began to manufacture true synthetic rubber, an industry which the Americans quickly duplicated when the treacherous Japanese attack at Pearl Harbour led to the loss of almost all Allied supplies of natural rubber.

The Russians have been experimenting recently with various plants which contain some of the natural attributes of the rubber tree. Whether either synthetic rubber or any natural substitute will be found which can compete with the natural plantation rubber of the tropics is a question for the future. Some synthetic rubbers are, as will be seen later, in certain special characteristics superior to natural; for instance, in resistance to air, light, oil, and acid. Tyre manufacturers, however, continue to prefer the natural when available, for although "Buna S" synthetic gives 30 per cent better mileage it deteriorates at over 50 m.p.h. because of inordinate generation of internal heat; so that, as tyres constitute by far the largest use for rubber, it may reasonably be expected that natural will be as important in the future as it has been in the past.

John Boyd Dunlop on his bicycle. (See Chapter II.)



ıerial view of Fort Dunlop, Birmingham. The building in the top left-hand corner is the huge Base Stores. (See Chapter II.)

CHAPTER II

JOHN BOYD DUNLOP AND WORLD TRANSPORT

MANY years ago Lord Lugard, after Cromer and Curzon the greatest Administrator of the nineteenth century, wrote: "The material development of Africa may be summed up in the one word 'Transport'." Transport indeed is the ultimate measure of civilization, upon which it exerts a steadily increasing grip—on the whole, for good. The conditions of transport afford a better test by which to measure a nation's standard of living than almost any other. In man's early history highways were few and were poorly constructed, and progress was so slow as to be almost incredible in this age.

The Romans were the first to realize the advantages and the wisdom of good roads. Throughout Europe and in this island of Britain it was their *via munita*—their "fortified," strong-built way—which assured strategically and developed economically their mighty civilization, thus anticipating by nearly 2,000 years the railway, and the *autobahn*. It is significant that the road-building programme of the Romans stopped short at the borders of what later became modern Germany, when internal troubles in Rome caused the recall of the legions who were building the roads and humanizing the barbarians. But for this unfortunate Roman situation the German tribes might have become humanized also.

Britain itself is the best evidence of how transport civilizes; and how quickly things go backward if they do not go forward. After the Romans left this country about 1,500 years ago, the roads were neglected and the standards of life in Britain insensibly slipped back. It was centuries before the same civilizing force was put to work again and progress resumed.

To-day the world is so full of good roads that it is almost startling to learn that the invention on which these good roads are founded was only patented 58 years ago. It was the pneumatic tyre more than any other single invention that changed our road-world from that of the horse and buggy to that of the motor car. I can well remember Lord Kitchener, as British Representative, urging the Egyptian Government to the then revolutionary step of providing their fourteen *Mudirs*—provincial Governors—with cars, ample petrol and instructions to be on the roads constantly and everywhere. Few of these Pashas were lightweights, none enjoyed bumping; and it was surprising how rapidly "the crooked became straight, and the rough places plain."

In the short space of three or four decades, the pneumatic tyre, first with human power in the bicycle and then allied with the internal combustion engine in the motor vehicle, did more to alter the face of the world and the speed of living than anything that had happened in the preceding three or four thousand years. That transition, so startlingly swift viewed historically, was, in the main, the work of one man, John Boyd Dunlop.

He was born in the little Ayrshire village of Dreghorn on the 5th of February, 1840. His father was a farmer, and the boy grew up with a love of farm animals and all that pertained to their well-being. He was sent to study at the Royal Veterinary College at Edinburgh and was a fully-qualified veterinary surgeon at the early age of nineteen. When he was twenty-two he went to Belfast, and built up a professional reputation that made him a national figure.

Much of Dunlop's time was spent driving his dogcart along country roads on visits to farms where his services were wanted. The cart was uncomfortable, the roads were miserable, so that the poor doctor anticipated by half a century the aches and pains of the Egyptian Pashas. These jolts, after a long process of development, resulted in what we see to-day as the finished rubber tyre, used for an innumerable variety of purposes, in peace and in war, by land, on the sea and in the air.

For Dunlop conceived the idea of an air-filled tube tyre.

Tyres in themselves were no novelty. The Pharaohs tyred their chariot wheels with leather[1]; and before the middle of the nineteenth century solid rubber tyres were already in use for the primitive bicycles and tricycles and for children's toys. In 1887 Dunlop had a ten-year-old son, Johnny, who had a tricycle; it occurred to him that here was a chance to test his idea that man might travel on rubber and air, fantastic though such a conception would have appeared to most of his contemporaries.

First, he cut a wooden disc of about sixteen inches in diameter. With sheet rubber ⅛ of an inch thick he made a tube, inserting at the union of the two ends a small air-inlet pipe like that of a football. Inflated with a football pump and the inlet closed, this primitive pneumatic tyre was secured to the rim of the disc by means of a covering strip of linen nailed to the wood. The first Dunlop tyre was now ready for the initial and—as it proved—decisive and epoch-making test. Into his business yard he took his pneumatic-tyred disc and the detached front wheel of the tricycle, with its tyre of solid rubber. It was the front wheel, as being typical of the best kind of wheel then known, which he first submitted to the test. He sent it trundling along the yard, but it failed to go the full length, wobbled and fell over. Using as nearly as he could judge the same force, he then tested the disc. It covered the length of the yard and rebounded as it struck the gate!

[1] "Leather was used for . . . the tyres of chariots, those on the miniature chariot of Sitamûn (XVIIIth Dynasty, about 500 B.C.), being still in perfect condition." *The Legacy of Egypt*, Oxford, 1942.

This convinced Dunlop that he was on the right track, and two months later he conceived a more ambitious experiment. He bent two strips of elm wood 9 feet long, 3 inches wide and ¼-inch thick into hoops about 3 feet in diameter, and riveted the ends together. He then made two air tubes of the finest sheet rubber $\frac{1}{32}$ of an inch thick, drew them into canvas tubes, and inserted a small air supply tube before joining the ends together with rubber solution. The valve was of the simplest type; a strip of rubber secured across the inner end of the air supply tube and thus forming a non-return valve. The canvas cover or jacket was covered with a thickness of sheet rubber, with two extra thicknesses on the tread. The tyres were fixed with solution to the wooden rims, and the rims were secured to the rear wheels of Johnny's tricycle with copper wire. They were finished on the night of 28th February, 1888, and Johnny immediately went for a trial run in the moonlight. That night was the turning point for transport, civil and military, neither of which on wooden, metal or even solid rubber tyres could ever have exceeded 15 or at most 20 m.p.h. For the heat generated in solid tyres driven above that speed breaks up their structure, whilst in pneumatic tyres air takes the strain; minimises the impact and so becomes the supremely effective "load-cushioner."

It was obvious that the tyres were lighter, faster and much more comfortable, but would they wear? The question was soon answered, for when they were examined next morning not a scratch nor a mark could be found.

Dunlop was now convinced that he had something of industrial value, although it never occurred to him that enormous changes affecting the whole world were to follow from his experiments. Verily, "he builded better than he knew." He went ahead making improvements and in July 1888 took out a patent for his invention:

"No 10607 A.D. 1888

Date of application: 23rd July 1888

PROVISIONAL SPECIFICATION

"I, John Boyd Dunlop, Veterinary Surgeon, 50, Gloucester Street, Belfast, do hereby declare the nature of this invention to be as follows:—

"A hollow tyre or tube made of india-rubber and cloth, or other suitable material, said tube or tyre to contain air under pressure or otherwise and to be attached to the wheel or wheels in such a method as may be found most suitable.

"Dated this Twentieth day of July 1888.

JOHN BOYD DUNLOP."

That document may be called the foundation stone of the entire massive edifice which to-day constitutes the Dunlop Organization. It is the Magna Carta of their world activities.

Dunlop had been a customer of a firm of Belfast cycle dealers named Edlin & Company. This company now began, under his direction, to make bicycles suitable for the new pneumatic tyres. Cycle racing with hard tyres was one of the most popular sports of the time, but when meetings were opened to the new pneumatic tyres they quickly demonstrated their superiority from every point of view. The public, both professional cycle racing men and those who rode for pleasure, took them up with enthusiasm and they were soon in use everywhere. Dunlops, from that beginning down to the present day, are and have always been the largest manufacturers of bicycle tyres.

Founding of the Dunlop Company

It became apparent to John Boyd Dunlop that an opportunity now existed for the building up of a substantial business in the manufacture of bicycle tyres.

He had become associated with a Mr. Harvey du Cros, who was convinced of the great commercial possibilities of the invention and who was familiar with the details of getting such matters going. Together they organized the Pneumatic Tyre Company in Dublin.

The prospectus was issued in November 1889, with an authorized capital of £25,000. The objects of the Company were the acquisition of Dunlop's patents and of the businesses of Edlin & Company in Belfast and the cycle department of Booth Brothers in Dublin. Proclaiming the advantages of the new pneumatic tyre, the first prospectus declared it "indispensable for ladies and persons with delicate nerves"—a gravity-removing recommendation.

The business grew with great rapidity and many new inventions looking to the improvement of tyres and of bicycles began to appear. Many of these were bought up by the Company and incorporated in its rapidly expanding output.

The original factory in Dublin soon proved too small, and the manufacturing business was transferred to Coventry, then as now the heart of the cycle industry. Soon the Coventry premises were outgrown and another move was made to Aston Cross, Birmingham. This too, proved inadequate, and it was decided to make provision for large-scale expansion. In 1916, therefore, 400 acres of land were purchased at Erdington, Birmingham, and the building was started of what is now the "tyre town" of Fort Dunlop, with its own locomotives and transport system, fire brigade and ambulance services, canteens to feed the armies of workers and sports fields for their recreation, and a power station to supply enough steam, electricity and water for the needs of a small city.

CHAPTER III

THE DUNLOP RUBBER PLANTATIONS

IT was in 1910, twenty-two years after the manufacture of the first Dunlop pneumatic tyre, that the Company turned its attention to the growing of its own raw material. There was much discussion in the industry as to whether plantation rubber would be suitable for the manufacture of tyres and other rubber products, and many experts were against the proposal. Indeed, the first plantation rubber, amounting in all to four tons, had only appeared on the market in 1904, and little about it was known.

We have seen how the price of rubber in 1910 had been manipulated by the second Brazilian rubber pool to a point where the product fetched 12s. 9d. a pound, a price which threatened to hamper the growth of the motor car industry, then just emerging into world importance. Once again in history the price boosters had opened their mouths too wide, compelling an ultimately fatal competition.

Dunlop first acquired properties of moderate size in Malaya; beginning in Malacca and in the States of Negri Sembilan and Johore. The first World War made it evident that rubber had become such an essential war munition that the nation's life in the future might depend upon having ample supplies of it—as indeed proved true. The Company therefore embarked on a much larger development programme and during the war new and extensive areas were planted, mainly in Negri Sembilan.

Shortly afterwards a further large area was purchased in Johore. By the year 1926 more plantings were undertaken until the total cultivated acreage amounted to 85,000 acres—the largest area under one ownership in the British Empire. This great property is now owned and managed by "Dunlop Malayan Estates Ltd."

The Company was one of the first to utilize on these vast expanses the method of budgrafting the rubber trees: grafting, that is, buds from carefully selected trees (known to be high yielders) on to seedlings grown from ordinary seed; and now practically the whole of its estates are being developed in this way. The second World War, entailing the suspension of operations from the time of the Japanese invasion, has interrupted the study of budgrafting results, but there are reasons for hoping that yields per acre may be raised from 400 pounds to more than 2,000. Should this prove so, budgrafting may tell decisively in the competition with synthetic rubbers which must hereafter be faced.

During this period a further radical improvement was made in the method of treating the crop for export. Ordinarily the white creamy latex as tapped from the tree is coagulated and dried in the form of sheet or crêpe. This makes it necessary for the rubber to be broken up by the use of heavy machinery before it can be used for manufacture. Until after the 1914-18 war, difficulties of transporting the latex and the absence of any known process of manufacturing directly from the uncoagulated liquid held up all developments. Dunlop's deep interest in the manufacture of rubber articles direct from liquid latex led them to acquire in 1930 universal rights for a patented process, whereby the latex from the tree is treated by centrifuge in such a way that the water content is reduced by 50 per cent, the rubber content raised to 60 per cent and all impurities and foreign matter thrown out so that the resultant product is acknowledged as the finest concentrated liquid latex in the world to-day.

This concentrated latex was shipped at first in kerosene tins and then later in steel drums, but now it is transported in bulk in special steamer tanks between huge bulking installations which have been set up at Singapore, Liverpool and Boston in the U.S.A. with subsidiary installations in other parts of the world.

CHAPTER IV

HOW THE WORLD-WIDE DUNLOP ORGANIZATION IS MANAGED TO-DAY

FROM the small bicycle tyre business capitalized at £25,000 in 1889, Dunlop has grown to be a world-wide industrial giant. It now employs a capital of £40,000,000, and when world affairs return to normal will provide work for at least 70,000 people in its various enterprises. The parent company in Great Britain has 60,000 shareholders, and there are altogether 90,000 shareholders if all the companies in the group are included.

In 1906 the organization extended its interests from the making of bicycle tyres to the making of cycle rims and motor car wheels. In 1910 the Malayan plantations described in Chapter III were started. In 1914 the company became interested in the spinning and doubling of cotton for the production of superior fabrics for tyres of all types. Dunlop's Cotton Mill is to-day the largest under one roof in the British Empire.

In 1922 all rubber companies suffered catastrophic blows in the general collapse of the boom after the first World War. Dunlop was therefore reorganized both financially and administratively. Sir Eric Geddes and Sir George Beharrell, who had won great reputations as administrators during the war, came in as Chairman and Managing Director; and under their direction many important and far-reaching changes were carried out.

One of these was the decision that the Company had become too dependent upon the motor and cycle industries for stability, and that a broader basis was necessary. To achieve this Dunlop in 1925 acquired the Charles Macintosh group of companies. These were engaged in the manufacture of a wide range of products using rubber, including proofed garments (known as "Macintoshes" after the pioneer who had founded the Company), footwear, sports goods, and general rubber goods of all kinds. The new acquisitions were submitted to an intensive reorganization; the unprofitable and the unsuitable were eliminated and the profitable developed.

Since then Dunlop has never ceased to expand. One development of first-rate importance was the invention during the inter-war period of latex foam cushioning sold under the now famous trade name "Dunlopillo." This is produced by frothing rubber latex and vulcanizing it in the frothy condition, thereby making a porous and exceptionally resilient substance destined, experts believe, to achieve a position only second (perhaps even equal) to tyres.

In the 1930's the growth of the aircraft industry saw an impressive expansion of Dunlop's output of aeroplane tyres and wheels and braking equipment. At this time there were also important overseas activities. Meeting the natural desire of Dominion Governments to develop secondary industries, Dunlop—which already owned factories in America, Canada, France, Germany and Japan and was largely interested in the Australian Dunlop Company—set up further large factories, in South Africa, Ireland and India. The wisdom of this policy was amply demonstrated in the second World War.

The control of Dunlop is vested in a Board of Directors, which consists partly of whole-time executives of the Company and partly of men of high business and financial standing who are not employed by it. The managing members of the Board comprise a whole-time Chairman, Sir George Beharrell, D.S.O., a Managing Director, Mr. G. E. Beharrell, a Director of Production, Mr. A. Healey, and a Director of Distribution, Mr. H. L. Kenward. The Director of Production controls the works organization at all factories in Britain and acts in an advisory or supervisory capacity to overseas factories. Sales and distributions are controlled by the Director of Distribution. There is also a Director of Overseas Sales, Mr. J. L. Graham, and a Financial Comptroller, Mr. J. H. Lord.

The sales and distributing organization is, owing to the great diversity of products handled, trade involved and class of customer, extremely varied both in composition and in methods. There are six Sales Divisions:—Tyres, General Rubber Goods, Footwear, Sports Goods, "Dunlopillo" Cushioning and Aviation Products; and five associated companies, Dunlop Clothing and Weatherproofs, Dunlop Special Products, Dunlop Cotton Mills, Dunlop Rim & Wheel Co., and Semtex Ltd.

In addition to direct sales many large transport owners, such as the London Passenger Transport Board, and very many corporation 'bus and tramway departments, purchase their tyres on a mileage basis. That is to say, Dunlop supplies and also maintains their tyres, and they pay so much for each mile run.

The nodal point in a great organization like Dunlop is where orders, whether for home or overseas, are passed to the factories for production. The key department at this stage is the Planning Department. Having completely surveyed the home and export orders from the Sales Department, the Planning Department puts a monthly and weekly programme before the Production Department, which "breaks down"—estimates—these requirements so as to ascertain the necessary daily deliveries of materials in quantities and qualities. All stocks are checked daily and the Planning Department makes a weekly survey of progress. It also forecasts labour requirements and informs the Employment Manager. The Planning Department, however, stops short of methods of production. These are the responsibility of the Technical Department, which controls

Research, lays down the processes to be adopted and keeps representatives on the floor of the workshops to see that specifications are followed.

Both the Planning and the Production Departments are under the Works Manager, whose scope includes planning, production, employment and welfare, management of employees, engineering and maintenance (which at Fort Dunlop involves no less than 1,600 engineers), inventions and patents, and stores.

An essential part of the factory organization is the Joint Factory Council, which consists of two sections in each factory: the operatives' section, elected by departments, each department having one representative for every 100 persons employed in it; and the management section, where the representatives are nominated by the management. The management representatives are fewer in number, but no decision can be taken unless both sides agree. The Joint Factory Council does not deal with basic rates and conditions, which are the subject of agreement between the industry and trade unions, but it does deal with all other matters affecting employment, though, of course, only in an advisory capacity.

There remains the question of control. The general principle adopted is to decentralize management, leaving initiative to departmental and sectional managers. It is however the Company's policy to centralize such services as purchasing, insurance, technical information, research and legal advice, together with certain branches of the administrative and accounting work such as banking, and taxation (now—as most of us know!—highly specialized and extremely complex).

The fabrication of tyres predominates throughout the rubber manufacturing industry of the world, and, naturally, the strength of the tyre production industry in any country is affected by the strength of its motor vehicle producing capacity. In the past this link has given the great American tyre companies a considerable advantage.

The Dunlop group of companies has however been able to compete in export markets with the greatest American and Continental tyre companies, and has in fact exported a larger percentage of its products than any other leading tyre company. This export trade was built up by long years of hard work, accompanied sometimes by bitter experience. It has been and will be maintained by skilled representation in export markets, by skilled supervision at home, by continual enterprise and a ceaseless watch over costs.

CHAPTER V

EXPORT MARKETS: HOW DUNLOP OPERATES OVERSEAS

THOUGH every great British industry would prefer to manufacture its goods in Great Britain, this is not always practicable. Nationalisms and local patriotisms have combined to make export and overseas trade a vastly different, and a much more complicated affair, that it was even half a century ago.

Dunlop's world trade organization has had to be built in such a manner as to fit into a widely differentiated group of national economies. In hardly any two countries can it function in exactly the same manner. Organization and representation must fit each individual market. The goal which this world organization and leading exporter of British goods and British standards strives to maintain has thus been stated:—

> ". . . to ensure that wherever a man—or a woman or child for that matter—wishes to buy an article included in the wide range of Dunlop manufactures, he shall be able to obtain it at least as easily as any competitive product. This is a hard saying since it implies that Dunlop products should be available in every shop or store interested, but it is a good objective and the Company would think they had fallen far short of their aim if their products were not available at least in the main centres of distribution of any country they are free to enter. This proviso must be made because there are countries which have established rubber manufacturing industries by means of tariffs so high that some of our products are excluded."

In the attainment of this goal the Company have to consider every country in the world separately on its idiosyncrasies: population, standard of living, political stability or otherwise, roads, communications —all have to be analysed as they affect the distribution of the Company's goods. They may decide to establish a factory; to set up their own sales depots; sell through a warehousing agent; or to a local distributor, leaving him to make his own arrangements; or, finally, they may sell to shipping houses in Britain, who act as purchasing agents for individual customers.

Generally speaking, when dealing with a well developed country with a good system of roads and a population with a standard of living which enables it to employ mechanical transport on a large scale, then

the establishment of a local tyre factory is fully justified; and it is certain that, if Dunlop is not willing to set up its own plant, some other leading tyre manufacturers, probably of foreign nationality, will do so. In considering the pros and cons of this difficult problem one has to bear in mind the well-being of the British Empire as a whole, not only that of the United Kingdom. The benefit to the Empire as well as to the United Nations of the widespread Dunlop organization was strikingly demonstrated in the past war.

Since tyres are the backbone of the rubber manufacturing industry, the probable demand for these is always the first consideration of any rubber company in deciding whether to build a factory. Once the tyre factory is established, however, there is a natural tendency to extend its range of manufacture. Plants in the Dominions are now making a number of accessories, general rubber goods and sports goods, and such extensions will undoubtedly spread in the near future.

The Dunlop organization in countries where it has its own factory is necessarily comprehensive. It is in fact, in its range of departments, depots and staffs, a miniature of the central parent company in Great Britain.

Next comes the market which receives its supplies of Dunlop products from outside its own borders, but where the demand is on a scale sufficient to justify the establishment of branches. The system here is practically the same as the distributive organization established in those countries where Dunlop draws its supplies from a local factory. Even in countries where the demand only justifies doing business through a local agent, acting on a fixed rate of commission, it is usually expedient to have also a Dunlop representative resident on the spot. This strengthens control over sales, while the representative's expert knowledge of the products is of the greatest help to the agent.

The problems involved in setting up overseas organizations can be illustrated by the Dunlop factories in India and South Africa. It would be difficult to find a greater contrast between any two markets than between these two. In India there is a population of about 440 millions, but with only about 120,000 motor vehicles. In South Africa the population is about 11 millions with some 370,000 motor vehicles. The relationship between the standard of living and the motor vehicle could hardly be better demonstrated, particularly when it is remembered that the high cost of living standards in South Africa are confined to the $2\frac{1}{4}$ million people of European origin; who thus employ over thrice as many cars as do the 440 millions in India. As would be expected, most of the Indian vehicles are lorries and buses, whereas in South Africa private cars are in a majority.

Population also shows its effect in cycle tyre sales, which are far greater in India than in South Africa. Nevertheless, the bicycle is still beyond the means of the vast majority of Indians, so that any improvement in their

economic condition would make itself quickly felt in Dunlop cycle tyre and accessory sales.

Many products other than tyres are made by both the Indian and South African factories; their number and variety will doubtless increase when world affairs become more normal. I shall show in a later chapter how important was the war contribution of these factories. But for their existence and for the vast quantity of tyres and other essentials they produced, the problem of maintaining adequate supplies for the British and Allied military forces in the Middle East and South East Asia must have proved almost insoluble.

CHAPTER VI

WAR'S OUTBREAK AND THE HEAD OFFICE: SAFETY OF RECORDS, STAFF AND OPERATIVE PROBLEMS: WAR SAVINGS CAMPAIGN

AFTER Munich it became clear to the Directors that the vast Dunlop organization must be prepared for the possibility of war. This involved many important and difficult decisions, affecting the Company's business and organization at home and abroad.

It was obvious that London would be the main target of enemy air attacks, that the head office in St. James's House, St. James's Street, S.W.I. would be in the front rank of battle and that in the national interest it would be foolhardy to expose the chief officials and directors of such a key industry as Dunlop to the risk of being all wiped out in one place. It was also clear that there must be no delay in devising means of safeguarding the Company's records, share registers, pension scheme data and other essential documents, the loss of which would have caused serious inconvenience. A central strong-room was provided at Fort Dunlop, and many important papers were sent there for safety. Where suitable they were duplicated by micro-photography, the process which proved so useful to the nation's banks in the air raids, so that in one way or another little chance remained that the enemy would seriously damage the Company's accounting or managerial system.

The first problem was solved, so far as could then be foreseen, by the purchase of a country house at Wardington, near Banbury, in June 1939. Sir George Beharrell and Mr. C. A. Proctor, then Managing Director of the Company, established their headquarters here, and were able from this central position to keep close contact with London and the Company's various factories in the Midlands and the North. When the war began, meetings of the Board took place sometimes at Wardington and sometimes at St. James's House; when necessary—in the air raid shelter which had been constructed there in the basement. St. James's House had the good fortune to escape a direct hit, but it was considerably damaged and the wisdom of removing the records and control staff to a safer place in the country was manifest.

It was necessary to establish a system of rapid communication by which contact could be maintained between Wardington, St. James's House and the various factories. This was done by means of fast courier cars and motor cycles. But there was always a risk—and the danger was a very real one in the early days of the war—that road transport might

The various special Savings Weeks have always brought excellent results from the Dunlop organization, and the Company allowed its premises to be utilized in several ways to assist the campaigns. Thus at Fort Dunlop the Joint Factory Council Chamber was specially set aside on all these occasions for display purposes, quite apart from the Savings Bureau, which has become a permanent feature of the works. Savings trolleys paraded through the works at appropriate times and visited all shops regularly on pay-days.

The following figures record the actual amounts saved by Company employees in the purchase of savings certificates and stamps in the period 1940-1946, but exclude the considerable amounts invested in savings banks, Government bonds and other sources of thrift:—

1940	£45,412	1943	£150,892
1941	100,983	1944	164,678
1942	100,250	1945	119,453

WAR SAVINGS ACTIVITY AT FORT DUNLOP

Above: The travelling Cinema Van. (See Chapter VI.)
Below: The Works Savings Bureau.

Conservation of Rubber. A large amount of reclaim rubber was obtained from used tyres such as these. (See Chapter VIII.)

SECTION II

DUNLOP'S CONTRIBUTION AT HOME

CHAPTER VII

DUNLOP EXPERIENCE THROUGH WAR PERIODS: NATURAL RUBBER ABUNDANT; NATURAL RUBBER EXTREMELY SCARCE; THE COMING OF SYNTHETIC

WHAT I have written up to this point has been in the nature of a Prologue. We now come to the first unfoldings of the main drama.

Of all industries involved in the war effort, rubber sustained the heaviest blow by enemy action against its most essential material resources. The industry had to face and solve tremendous problems resulting from the loss of Malaya and therewith of its primary raw material, and the consequent necessity of changing to the use of synthetic rubber while at the same time maintaining the output of essential products. These complications imposed a heavy strain on the Dunlop Organization, the more severe because of its leading place in the industry in Great Britain. In the following two chapters an account will be given of the difficulties encountered and of the remarkable success achieved in overcoming them: not only for the particular needs of the Dunlop factories, but for the rubber manufacturing industry of the United Kingdom as a whole. Almost every new process discovered was made available to other manufacturers as a further contribution to the total war effort.

War-time production in the Dunlop factories falls into three well-defined periods:—first, 1939-1941, when natural rubber supplies were abundant and the most urgent call was for maximum production; second, 1942-late 1943, when there had to be the strictest conservation of rubber because of the loss of the main rubber-producing territories, Malaya and the Netherlands East Indies; third, from late 1943 onwards, when American synthetic rubber became increasingly available.

During the first period—until the end of 1941—plenty of natural rubber was available; indeed, in 1940, 13 per cent more was consumed than in 1939, in 1941 22 per cent: an expansion the more notable in that it took place during a period when work was frequently interrupted by aerial attack and many Dunlop installations seriously injured by enemy bombing.

At the beginning of the war, the problem of conversion from peace-time products to those essential for war purposes was of first importance and urgency. Car tyre production was drastically cut, and plant and processes were changed to provide for the greatly increased requirements of special tyres for military vehicles, tanks and aeroplanes. Golf and tennis ball manufacture was continued awhile for export and currency purposes, but the increasing demands of the Services led to its curtailment and ultimate cessation. Labour and floor space were then quickly utilized in turning out more and more products directly required for the war effort—particularly giant tyres for heavy bombers. As latex supplies were being maintained, Dunlopillo production went on apace: among new products a special type of rubber sheeting based upon a latex process was developed for use in the bullet proofing of aircraft fuel tanks (making them self-sealing after penetration) and nearly a million square yards were produced.

Apart therefore from some dislocation of supplies of accessory materials required in rubber manufacture, owing to enemy action, there was in this phase of the war no acute raw material problem, and the main effort in the factories was concentrated upon plant conversion and increased production.

1942-LATE 1943

The dramatic and treacherous conquest by the Japanese of Malaya and the Netherlands East Indies and the segregation of other rubber-producing territories in the Far East had immediate repercussions on the rubber manufacturing industries of the United Nations. Almost overnight, a potential supply of rubber amounting to about 1,300,000 tons a year, or about 90 per cent of the world's supply, was lost to the Allies.

Governmental action was immediately taken in this country and in the United States to meet the new position, and in the United Kingdom Dunlop played the leading part in advising Government officials on the measures to be taken to conserve rubber. A department of rubber control was set up in the Ministry of Supply. Mr. F. D. Ascoli, London Director of Dunlop Malayan Estates Ltd. was appointed Rubber Controller, and associated with him were several members of Dunlop's Technical and Production staff.

Broadly, the aims were:—

(a) To eliminate the manufacture of all non-essential rubber products;
(b) To utilize to the full rubber products that had completed their first life, by grinding the rubber to a fine crumb, or by passing it through a suitable reclaiming process, and incorporating these materials in new stock;
(c) To reduce to a minimum the percentage of rubber hydrocarbon in all compounds, and, in some products, to replace new rubber completely by reclaimed rubber;

(d) To re-design products where possible in order to use a smaller volume of rubber;
(e) To develop rubber substitutes from available raw materials, and
(f) To maintain the flow of essential rubber products of reasonable serviceability, with full regard for the need for rubber economy.

The effect of executing these measures is strikingly brought out by the fact that Fort Dunlop consumption of natural rubber in 1942 was cut by 40 per cent compared with 1941, with a further reduction of 5 per cent in 1943.

LATE 1943 ONWARDS.

While British rubber manufacturers were wrestling with the problem of conserving natural rubber, a colossal programme of synthetic rubber production was being developed in the United States, and was by 1943 well under way. At Fort Dunlop the first small samples of American synthetic known as GR-S type became available in mid-1942, and were made up into treads for small tyres for test purposes. The flow of synthetic rubber for small scale production began in 1943, and although the amount available that year was scant (being only 3 per cent of the rubber used at Fort Dunlop) it was enough to show what the factory would have to face in converting tyre manufacture from natural rubber to synthetic.

Experimental work in the factory had proved that new methods would be required with GR-S. To make these effective, immense increases of plant had to be provided, involving reorganization of lay-out within existing buildings; a heavy task for the Engineering Department because it had to be performed without substantial interference with current production—as if a man should ride a bicycle while he was making it. However, the gap created by the loss of natural rubber could only be effectively closed by the large-scale use of synthetic, and the plant alterations were made with such good effect that the factory was able to show a usage of synthetic rubber in 1944 nearly equal to that of natural. In the first half of 1945 conversion to synthetic rubber was well in excess of 60 per cent.

GR-S synthetic rubber requires carbon black to give it strength, and shortage of the required types of black created a supply problem in 1945. Measures taken to economize in the use of black proved effective in meeting, what, in comparison with the rubber shortage which the nation has survived, may be classified as one of the lesser supply crises.

The use of rayon as a tyre fabric (particularly in giant tyres) was greatly extended as the conversion to synthetic rubber developed. The experience of Dunlop textile experts had enabled this change to be introduced during the preceding years of shortage, with a view to conserving natural rubber, as the thin rayon cords in these tyres lie closer together than do the cords in a normal cotton casing, with the saving in the rubber insulation of a fifth of a pound of rubber hydrocarbon for

every pound of rayon used. It was found that in giant tyre construction with synthetic rubber rayon gave other substantial advantages over cotton; thus previous experiment had prepared the way for the conversion to synthetic rubber which was to take place later.

All these problems imposed heavy burdens on those responsible for production and technical matters at the various rubber factories, and particularly on Mr. W. W. Foster, Mr. F. G. W. King and Mr. E. A. Murphy, respectively the Production Manager, Technical Director, and Manager of the General Developments division at Fort Dunlop, and on Mr. S. A. Brazier and Mr. G. Livings, respectively Technical Manager and Production Manager at Cambridge Street, Manchester. No less severe was the strain on those responsible for the provision and maintenance of machinery at these factories—Mr. H. Willshaw, O.B.E., and Mr. F. Walker. Mr. Willshaw rendered important services also as Chairman of the Birmingham Reconstruction Panel.

CHAPTER VIII

RUBBER SHORTAGE CRISIS

TYRES

THE account of the transformation from the productions of peace to the requirements of war, given in the previous chapter, by no means covers all the technical difficulties encountered.

Although the complete loss of rubber supplies from Malaya and the Netherlands East Indies had not been foreseen, the possible curtailment of all kinds of imported materials by submarine warfare and other causes had of course been anticipated; and the technical staff of Dunlop had, before the war, made a survey for the Board of Trade of the probable effects of war on the supply of such raw materials and the possibility of replacing them by Empire or home products. They were, therefore, prepared for the trials and tribulations of 1939 and 1940.

The stocks of materials held by the Company at the outbreak of war were mainly peace-time stocks, to which many other items had to be added when conversion to war production had been achieved.

As certain reserve stocks were held at the factories against the possibility of war, the curtailment of supplies had at first no serious effect on production. Difficulties in procuring some materials, however, soon began to diminish these factory reserves, and one of the first tasks for the technical department was to conserve materials which were going to be hard to replace, and to test substitutes offered from domestic or Empire resources.

French chalk, used to prevent rubberized fabrics from sticking together during manufacture, is a typical example. French chalk of the best grades had (paradoxically) been obtained from Italy prior to the war; it now became extremely scarce. A number of other powders were tried as substitutes, none quite successfully. Later, however, the position was eased by the import of talc and other equivalent materials from Canada. Until shipping shortage stopped supplies, an extremely good grade of French chalk was obtained from India: so varied are the resources of the British Empire.

In order to economize the use of crude rubber, steps were also taken to increase the supplies of suitable types of reclaimed rubber. The supply of scrap rubber became an important business, and Mr. Arthur Smith of Dunlop's Tyre Sales Division played a prominent part in the development of this. But until the supplies of natural rubber in Malaya and the Netherlands East Indies were cut off, many Government and Service specifications had prohibited the use of reclaimed rubber—a restriction which now had to be reconsidered.

The supply front weakened after the fall of France—extra shipping became more and more difficult to provide; and supplies of compounding materials, many of which came from overseas, were further diminished.

Special measures of conservation now became necessary, and one of the most important of those adopted at this time was a rapid increase in the remoulding of tyres. Towards the end of 1940 it was realized that remoulding would have to be adopted on the largest possible scale. It was already apparent that there was going to be a greater demand for aero and giant covers than Fort Dunlop could produce and that other quarters would have to be found.

This need for other quarters was further accentuated by the heavy air raids that were then taking place in the Birmingham district, and with the agreement of the Government it was decided to look elsewhere for remoulding premises. This led to one of the strangest linkings of old with new in British industrial history.

The Wedgwood pottery works at "Etruria," Stoke-on-Trent, are known throughout the world, and their gracious products are cherished wherever civilized man has set up standards of art and culture. The china and pottery industry was a casualty of war, and the Wedgwood works became available for other uses.

Parts of these works were built by Josiah Wedgwood, a potter from Burslem, when he first started business in "Etruria" in 1769—the birth year of Wellington, of Napoleon! It is hard to imagine a greater contrast than these early works, set in an environment of open fields and wooded tracts, primitive by modern standards, with the artisans working by candle light when daylight failed, and the uses to which they were put by Dunlop. Josiah Wedgwood as he sat peacefully creating English beauty for a world in which air raids, aeroplanes, motors, rubber tyres—rubber itself—were unimaginable, could not even in a nightmare have pictured the service his beloved works were to supply to his country nearly two centuries later.

Sir William Hamilton, who (besides being "Emma's" husband) was a lover of ancient art, realized the beauty and value of the antique "Etruscan" relics that were being exhumed in Italy at the time when he was British envoy to the Court of Naples. Hamilton had employed the finest French and Italian artists to make sketches of the cups, platters, vases, urns and wine pourers recovered, and these were published by him in 1766 and 1767. He had sent advance proofs of the drawings these volumes contained to various friends, amongst whom was Lord Cathcart. Cathcart showed them to Wedgwood, who, inspired by their beauty, decided to build a new pottery in a rural area where ceramics of a quality never before known in Britain could be produced.

These works, advanced for their day, are a startling contrast to a modern industrial plant, but they are, nevertheless, still usable and so strongly built that when an outworn steam engine was discarded some years ago dynamite had to be used before it could be dismantled.

Their unsuitability, judged by normal Dunlop standards, was more than counterbalanced by an excellent supply of dependable women workers. As the manufacture of china ceased in each of the old rooms the machinery used in the tyre remoulding process moved in. These machines steadily expanded until "Etruria" became the largest remoulding works in Britain, employing 800 people. Up to the end of 1945, they had turned out well over one and a half million tyres, repaired scores of thousands of tubes and performed a variety of other tasks which relieved congestion at many other Dunlop plants.

All these efforts could not, however, have met the situation caused by decreasing supplies of material and rapidly increasing demands for tyres by the fighting services and essential transport, had not a rigid control over the production and distribution of tyres been established. During the war the British public cheerfully accepted the necessity for the control by the Government of all essential goods and services. Modern Britain depends to such an extent on rubber-tyred transport of all descriptions that, next to food and clothing controls, tyre control probably affected a greater number of the population than any other wartime restriction.

It was natural that the Government should turn to Dunlop for much of the experienced advice which was needed to ensure that tyre control should contribute directly to the war effort, while disturbing as little as was humanly possible the nation's productive and distributive machinery. This was a tremendous task. It called for a wide knowledge of the needs of the nation's indispensable road haulage system, for a close estimate of the tyre stocks in the hands of dealers and others—for which no official statistics existed—and of the probable life of the tyres already on the road: as well as for the building up of an organization which should combine efficiency with fairness and which should, above all, meet the country's maximum needs. Much credit for the smooth working of the scheme was due to Mr. T. K. Lawler, who acted as liaison officer between the Ministry of Supply and the tyre industry.

It called also for a judicial attitude not commonly associated with manufacture and trade, which would have regard for the Briton's hatred of all regimentation not absolutely necessary in the common interest and peril. The Tyre Control had no difficulty in getting all the authority it wanted to carry out its decisions, but it was wise enough to heed Solomon's injunction "with all thy getting, get understanding." With its accumulated knowledge of Britain's tyre needs ever since tyres were invented, the Dunlop organization, through the officials they lent to the Control, were able to exercise a degree of understanding that contributed much to the admitted success which it achieved. Amongst these were no fewer than five Regional tyre officers, Messrs. J. Lewis, E. Bennet Roger, P. C. Welsh, E. J. Garland and W. P. Gardiner.

Through the active and wholehearted co-operation of the entire industry, the Control got into operation and worked smoothly in spite

of the grievous handicap that, as the supply of tyres for civilian use went rapidly downwards, the needs of the Fighting Services were multiplied beyond conception. Nevertheless, despite the difficulties with which manufacturers had to contend in using varied and untried substitute materials after the supplies of natural rubber ceased, it is worthy of note that not one essential passenger or goods service was ever held up through lack of tyres. For this happy result much credit is due to Mr. H. Shankland, Dunlop's Director of National Sales, who acted as liaison between the Government and the Transport Services.

A natural corollary of Dunlop's dominant position in the industry was that it suffered heavily, first through the loss of so many key men who were called into the Government service, and secondly through the disruption of its comprehensive selling and service organization all over the country.

One result of the Control was that Dunlop trade distribution points were reduced from upwards of 20,000 to 1,500. This involved a complete rearrangement of distribution systems and consumer contacts, all at the very moment when Dunlop employees were leaving by the hundred to enter the Armed Services or to serve in Rubber Control or in some other Government department. The men and women of Dunlop were not found wanting. Many men who had retired, returned; either to the head office or to one of the Company's depots. Women undertook work previously done by men, longer hours were worked, and the changed order quickly settled to regular routine.

For organization, the Control was vested in a Director within the Ministry of Supply. He, from the outset, sought the help of manufacturers, distributors and retailers, through the Associations to which each belonged. This co-operation proved entirely effective and by means of it every direction from the Ministry of Supply was carried out in a spirit of fairness and good will.

The Tyre Manufacturers' Conference, of which Mr. H. L. Kenward, Dunlop Director of Distribution, was President, had previously concerned itself mainly with commercial affairs. It was now invited to broaden its considerations to matters of technique and production in order to make sure that the best use was made of national resources and producing facilities. In this movement Mr. A. Healey, Dunlop's Director of Production, took a leading part, except for the period when his services were lent by the Company to the Government to act as principal adviser on the many problems connected with the introduction of synthetic rubber.

Later on, when synthetic materials of varying usefulness began to arrive, the Conference gave advice on how these could be employed to the greatest advantage. It also appointed a Commercial Advisory Committee to advise the Tyre Director in formulating and carrying out a distribution plan.

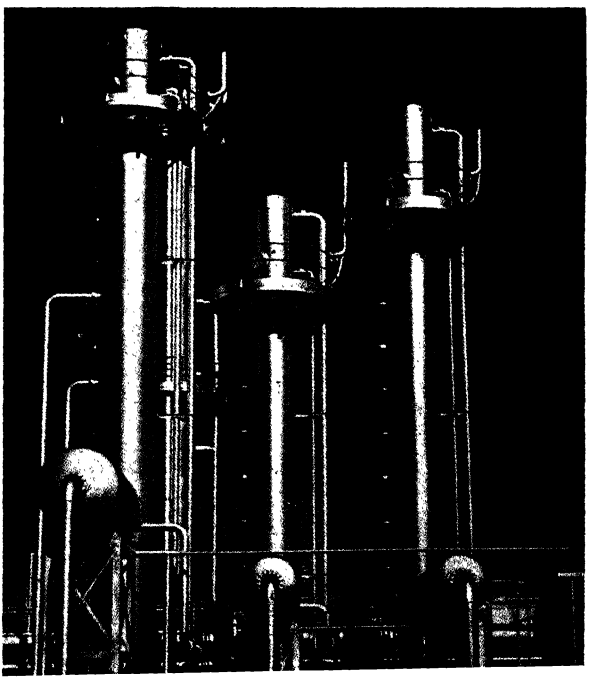
Tyre Control comprised a directorate in London (of which Mr. H. J. Holmes, one of Dunlop's District Sales Managers, became Director),

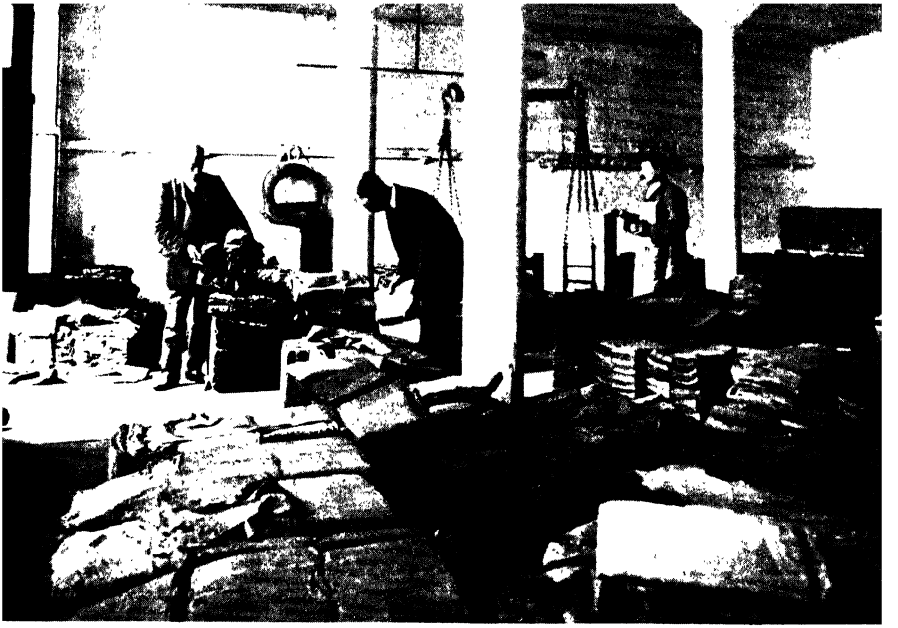
SYNTHETIC RUBBER PLANT.

Above: Giant Horton-spheres for storage of manufactured Butadiene. (See Chapter VIII.)

Below: Part of Butadiene production plant.

(Photographs from *Life*.)

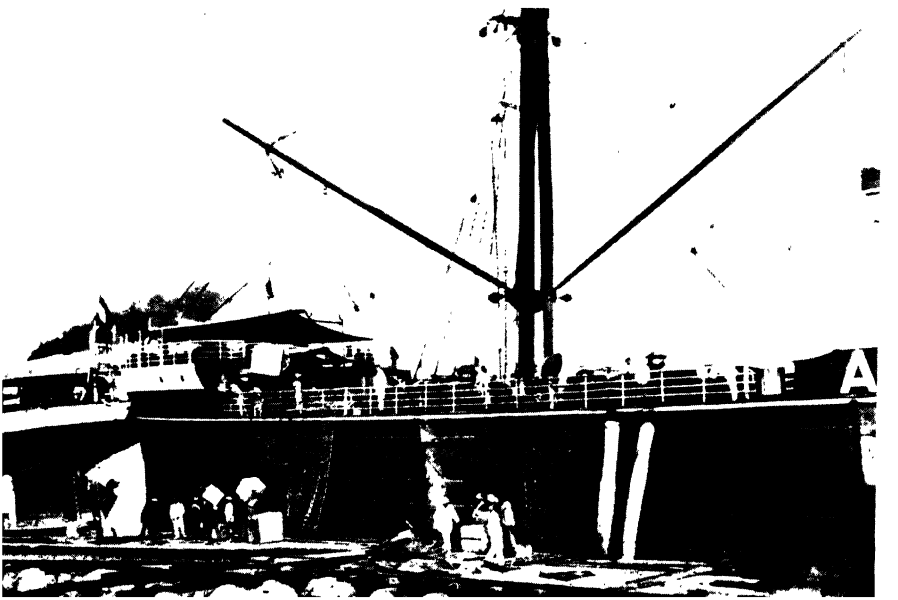




Above: Weighing and sampling rubber at a London wharf.

Photo British Rubber Publicity Association

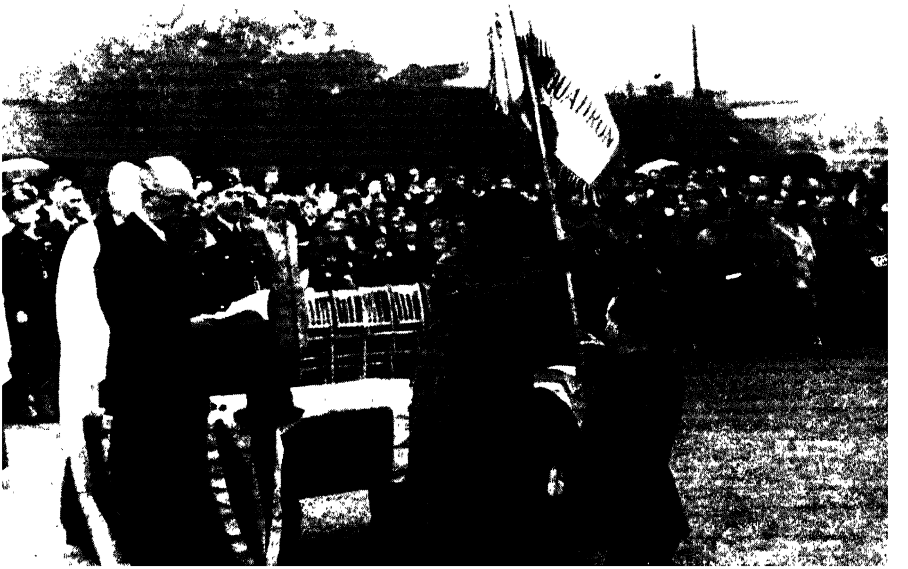
Below: Shipping rubber at Singapore.



Fire in Scrap and Rec

Above: Fort Dunlop Home Guard march past the Managing-Director, Mr. G. E. Beharrell at the saluting base. (See Chapter IX.)

Below: Sir J. George Beharrell presents colours to Fort Dunlop Air Training Corps. 6th June, 1943.



regional officers whose control covered areas coinciding with those of the Ministry of War Transport and divisional petroleum officers, inspectors and some 1,500 authorized depots. Authorized depots were established by the appointment of traders who had been active in tyre distribution. These were chosen partly on a geographical basis and partly for their experience and service facilities. Appointment was by license issued by the directorate.

This system resulted in a high degree of concentration and control which contributed greatly to the saving of tyres. Heavy vehicle operators were required to register with an authorized depot, and thereafter were compelled to obtain all requirements from this one source. Motor car users running with "essential" petrol coupons had to obtain a certificate of essentiality from their divisional petroleum officer, and to lodge this with a depot.

These depots played a necessary part in economizing tyres and prolonging their life. They were required to examine all tyres before removal, to draw attention to any vehicle deficiencies which might be causing unnecessary wear, and to decide whether new ones were necessary or whether further mileage was safely practicable. The depots made weekly reports of tyres needed to their regional officers, while manufacturers similarly reported what stocks were available. From these two reports the regional officer allocated available supplies where he considered them most needed.

All of this placed a heavy and hitherto unexperienced burden on both manufacturers and depots. A considerable amount of work in the way of forms to be filled up and reports to be rendered was unavoidable. Furthermore, the authorized depots had a tough part to play because they were the actual point of contact between the rigidly restricted supply for civilian use and the actual user. This called for tact, diplomacy and sometimes determined forcefulness in the face of strong personal appeals. All these qualities the depots showed, and they acquitted themselves well.

The Control had not been long in operation before it became clear that, in addition to distributing new tyres, there must be a national effort to salve every used tyre or other rubber product that could help to eke out future production. These consisted mainly of casings fit for re-use after being remoulded, and scrap to be used in reclaimed rubber.

The Control therefore set up central inspection depots to which all tyres removed by authorized depots were sent. These depots were staffed with experienced examiners and all tyres coming in were sent either to factories to be remoulded if they gave promise of further life, or to the Ministry of Supply scrap dumps.

In these salvage operations Dunlop was again called upon for aid. Although suffering from an acute staff shortage, the Company supplied experienced men for three of the inspection depots, which at the peak of their work handled from 20,000 to 25,000 worn tyres per month.

Mr. W. Parsons, Supervisor of Dunlop Service, played an important part in this vital activity. Mr. A. E. Lucas of the advertising department did excellent work for another very useful scheme—the preparation of tyre economy exhibitions which toured the country with notable effect.

A special technical committee had been formed to act as an advisory committee to the Rubber Controller in the event of war. Mr. S. A. Brazier, the Head of Dunlop's Technical Department at Cambridge Street, Manchester, was appointed Chairman of this committee, the main work of which was to give advice on problems connected with the shortages of raw materials. After the outbreak of war with Germany a survey was made at the request of the Ministry of Supply with a view to reducing the amount of natural rubber used for mechanical goods, so as to ease the shipping position. This work was already well under way when Japan entered the war.

The first step taken by this committee when the supply of natural rubber from Malaya and the Dutch East Indies ceased was to prepare a list of articles the manufacture of which could either be prohibited or placed under licence, so that the quantities produced by manufacturers could be directly controlled. These came under the general category of articles not required for the war effort or not considered essential to the life of the community, and articles which although previously made from natural rubber could in emergency be made from alternative materials not at that time in short supply.

The effect of these restrictions on the Dunlop General Rubber Goods Factory varied for different types as the war went on. Many articles in the first two categories had already been cut out to make room for war production. The new conditions drastically reduced the output of such almost essential amenities as moulded hot water bottles, household gloves and proofing—particularly waterproof garments.

As a further step to conserve supplies of natural rubber co-operative investigations were carried out by the leading mechanical goods manufacturers, with a view to reducing the proportion of natural rubber in all products, and in this work, too, Dunlop took a leading part. As a result, a number of orders were issued by the Ministry of Supply specifying maximum gauges or thicknesses, and restricting percentages of rubber. To economize in the use of reclaimed rubber, which was also in short supply, the maximum amount which could be used, and in some products the type of reclaim authorized, was also laid down.

Particularly important economies were the reduction in the tread thickness of heavy-tread giant tyres, and a simplification in cycle tyres to a uniform war grade. Retreading was also greatly extended, thereby saving much rubber and cotton in serviceable casings.

To speed examination of these various problems, Dunlop's technical departments were frequently asked to evolve new compounds with a lower percentage of natural rubber or to make sample components for the Government or Service Departments, on which trials could be

carried out. Specimens of raw material developed from home supplies, or materials offered for consideration by the Ministry of Supply, were also examined on behalf of the rubber industry, and an assessment given as to the type of product for which the material might be suitable.

The exceptionally good testing and laboratory facilities long established at Cambridge Street, combined with Dunlop's wide experience in the manufacture of most types of mechanical goods, were very helpful in carrying out this work quickly. In addition to its direct value to the Ministry of Supply, the work done notably assisted the general body of rubber manufacturers through the information bulletins circulated by the Technical Advisory Committee.

Reclaimed Rubber

As an example of this work, the supply of reclaim may be cited. Long before the plantations were lost to the enemy the problem of utilizing scrap rubber in tyres had received intensive study by Dunlop technologists. Therefore, when the urgent need arose for conserving new rubber, they were in a position immediately to recommend a programme for grinding suitable types of scrap (worn tyre treads, for example) and reclaiming other types, such as giant casings and tubes.

Within a few months this programme, which again involved changes in equipment and provision of new plant, was well advanced, and by careful application it was carried through without appreciably lowering standards of quality.

Unfortunately, just as the situation was beginning to improve, the principal reclaim manufacturing plants in the country were damaged by bombing. Here again Dunlop was able to help. In order to economize in the use of rubber it had been found necessary to curtail greatly the production of rubber footwear, and a scheme of concentration in which Mr. Ivor Davies, Manager of the Footwear Sales Department had taken a prominent part, had left a large section of the company's principal footwear factory at Walton, Liverpool, unoccupied. In this factory the Company's Footwear Division (under the direction of the Works Manager, Mr. R. C. Davies) developed in the nick of time a new (thermal) process of reclaiming which was independent of the type of plant previously employed. This greatly eased the situation. A number of samples of rubber reclaimed in the plants of other companies were also tested for the Ministry of Supply, until a satisfactory standard had been achieved by the newcomers. Several firms operating such processes with little experience were thus able to take advantage of Dunlop's reclaiming and refining experience to help the national effort.

Another problem the Company had to face related to moulded soles and heels and soling sheet. The finest grades had, prior to the rubber shortage, been made of relatively high percentages of natural rubber and specially selected grades of reclaimed rubber. There now began a

progressive campaign in saving natural rubber, which was replaced by roughly equivalent amounts of reclaim until all products, other than special types, were being made entirely of reclaim. None could pretend that the original quality was maintained: but the aim was to produce the highest possible standard of product and the largest possible output with the materials available.

What happened with reclaim is typical of the many technical and production facilities which Cambridge Street placed at the disposal of the Ministry of Supply and the Fighting Services, with results passed on later to other manufacturers to enable them to start production without delay.

One task of great national importance was the comprehensive testing of moulded components for the Admiralty. Many of these components were used in direct contact with explosives, so that chemical "compatibility"—as in other relations of life also sometimes explosive—was essential. Once again the Company took a leading part in the design of alternative compounds, the provision of test samples, and the production of components for Service trials prior to general adoption by the industry.

Standardized Fabrics

The experience of the Dunlop Cotton Mills, at Rochdale, was also utilized for the general benefit of industry in establishing standard fabrics for the manufacture of hose and belting. As shipping grew scarce, reserve stocks of cotton dropped and the grade of cotton used up to that time for belting was urgently needed for other war purposes. The large variety of yarns used by the makers of cotton ducks, sometimes amounting to thirty or forty different fabric "constructions," made planning in the spinning section difficult; moreover, it was not easy to transfer output from one mill to another when labour or other conditions necessitated a change in supply.

A special committee was therefore set up to develop standard specifications for the cotton fabrics used in belting, hose and footwear. Much standardization work had already been done by the Company's technical department at Rochdale, and the experience thus gained was placed at the disposal of the industry.

Ultimately four standard duck-fabrics were established for conveyor and transmission belting and eleven for hose-piping. For footwear, eleven fabrics formed the basis of standardization. These were chosen from nearly one hundred standard samples filed by manufacturers—a triumph of simplification.

In the design of these standard fabrics continual recourse was had to Dunlop's special knowledge; and it was gratifying to all concerned that, though Service experience of them was reviewed from time to time, not one modification was found necessary.

PROOFING

Proofing presented another awkward problem. The demand for ground sheeting for our own Forces and for Russia became far greater than could be met by standard practice; and a calendering process on which Dunlop had been working for some time was put into operation. By means of this, a maximum output of 100,000 square yards per week was reached, and for more than twelve months weekly production never fell below 60,000 square yards. The bulk of this sheeting was also printed with a camouflage design which Dunlop was the first to produce satisfactorily on a commercial scale. Here again, experience was passed to other firms.

When the Japanese overran Malaya and the Dutch East Indies the proofing section of the industry was naturally one of the first to undergo a drastic cut in the amount of rubber allowed, and before long natural rubber was only permitted for very special types. This led to a very extensive search for alternative materials, and the Company initiated two which were largely used as war emergency proofings until the supply of G.R-S. eased the situation.

The first was gelled (or jellied) rape seed oil which had not been used commercially up to that time for this purpose. Although it was at first used in conjunction with some natural rubber, Dunlop was able progressively to reduce the amount, and for nearly twelve months used a proofing wholly based on gelled rape seed oil.

In the meantime the Company developed an alternative all-reclaim proofing with which they were very successful. Supplies of the best reclaim had become extremely scarce and were earmarked for high priority work; but there was an increasing accumulation of miscellaneous wastes containing fabric, which could not economically be reclaimed by the normal processes owing to the poor yield. In co-operation with the technical staff at Liverpool, a special type of reclaim was evolved which could be successfully used for proofings, and was in fact so used until G.R-S. became available for this purpose.

SYNTHETIC RUBBER—G.R-S.

As samples of G.R-S. were received from the United States, they were allocated to various manufacturers, on the understanding that the experience gained would be passed on to the industry for the general benefit of all. Dunlop received allocations under this scheme for most products and did considerable work on its incorporation into compounds for hose, belting, mechanical moulding and sheet, ebonite, proofing, etc. The factory had to work at first with relatively low percentages of G.R-S., but it was soon in a position to incorporate higher precentages with the natural rubber allocations and to use these in conjunction with reclaimed rubber right up to the limit of the supplies available.

Acting on information thus obtained from the pioneer firms, a completely new series of schedules was introduced, again greatly reducing

the amount of natural rubber, and compelling the use of a higher proportion of G.R-S. or other synthetic, so that there went throughout the industry a progressive conversion from natural to synthetic rubber.

Wild Rubber

With the cessation of rubber supplies from Malaya and the Dutch East Indies, the authorities at home also turned to the supplies of wild rubber from Equatorial Africa. The types obtained varied a good deal in cleanliness and also in their vulcanizing properties, and once again the Company was asked to do a considerable amount of the necessary investigation work in order to establish conditions under which the rubber could be washed as free from dirt and grit as possible, the type of production for which it could be used, and the percentage of standard grades of rubber which could be replaced by it. Eventually, as the Ministry's scheme for washing and distributing got into its stride, most types of mechanical rubber goods had to be made with a large percentage of African wild rubber; owing to the wide variation of this much extra work was thrown on to the Technical Department.

Rubber Latex

Before the war Dunlop's had extensive interests in the manufacture of products direct from latex, and considerable floor space at Cambridge Street had been occupied in the manufacture of products such as balloons (toy and meteorological), household and industrial gloves, bathing helmets, hot-water bottles, Dunlopillo (also manufactured at Fort Dunlop) and Charnaux corset panels.

When war broke out a number of these amenities or luxuries for purely civilian consumption were either discontinued or curtailed. Later, owing to the need to conserve stocks of latex, Dunlopillo production at Fort Dunlop was drastically reduced, and was finally stopped in August 1942. Within a few months, the plant had been adapted for the production of a synthetic substitute for rubber called Thiokol, which was successfully applied to insulating rubber cables. By September 1944 over 700 tons of this material had been produced, a valuable contribution in a time of grave emergency.

The Cambridge Street Dunlopillo plant was restricted to special war items, such as pads used in clothing worn by air-borne troops to lessen the shock of landing; shock absorption pads made to protect delicate Service equipment, surgical pads, ear pads for flying helmets, lift seals for aircraft carriers, gun pads and sponge sheeting for self-sealing fuel tanks. Besides these, many thousand yards of woven felt were spread with latex for covering self-sealing petrol tanks.

Rubber boot and shoe production, which used a considerable volume of latex, had to be drastically reduced in 1942; and here again great versatility was displayed in adapting within a few months much of the redundant plant in the shoe factory to the large-scale reclaiming of rubber by the new process already mentioned.

CHAPTER IX

ENEMY AIR ATTACKS ON DUNLOP FACTORIES IN BRITAIN: HOME GUARD AND A.R.P.

As at other British factories difficulties were not confined to the technical problems of production and distribution: there was the ever-present threat of attack from the air and the more remote possibility of attack by land.

The Dunlop organization was a pioneer in the planning and execution of the air raid precautions which proved so valuable after raids began. In this Mr. D. J. Crabbe, the Company's Chief A.R.P. Officer, rendered important service.

Precautions had been started as early as 1935, and the first purchases of equipment were made in 1937. Methods of enemy attack changed considerably and the minimum standards of protection were revised more than once by the Ministry of Home Security, yet this original programme of shelters and organization drawn up in 1935-36 needed practically no alteration during the war—a notable tribute to the quality of the original plan.

Although Dunlop suffered heavily in air raids from time to time, the remarkable feature of the damage inflicted was its temporary character. Nowhere did the enemy successfully interrupt the production of war material for more than a brief space at a time. This was largely due to the manner in which the risk was spread: with thirty-one factories widely dispersed throughout the country, it was impossible for an air raid to do more than a limited amount of damage.

Besides its main factories, Dunlop took over many other premises early in the war to increase dispersion still further. Many important products were turned out in garages, and others in a colliery, a mining technical institute, an agricultural implement works, a brick works, a silk stocking factory, and a mineral water factory.

This great scheme for dealing with air raids cost money; by the end of 1942, when everything possible had been accomplished in the way of fire protection, rescue, anti-gas and casualty services, and black-out in thirty factories housing 25,000 workers, it had cost the Company £700,000.

The blackout was a heavy trial to factory workers. At Fort Dunlop alone it involved the darkening of 2,000,000 square feet of windows. In spite of the use of every possible means to secure adequate ventilation,

work in blacked-out factories, particularly in the summer months, imposed a serious extra strain on everyone.

Loss of working time during the air raid alerts was kept to a minimum in Dunlop plants through the roof-spotting system, which was not imposed by the management but was introduced at the suggestion of the workers themselves a considerable time in advance of its general adoption by industry.

The efficiency of the air raid precautions was equalled by the energy with which all repair organizations worked and the enthusiastic co-operation of employees of all grades. There were a great many acts of individual bravery during the raids. Perhaps the most spectacular of these which came to public notice was at the Gas Works adjoining the General Rubber Goods factory in Manchester. Here incendiary bombs were dropped on a gasometer. They were removed by an employee, Patrolman H. E. Furnival, at very great risk to his own life. For this he was mentioned in the *London Gazette*.

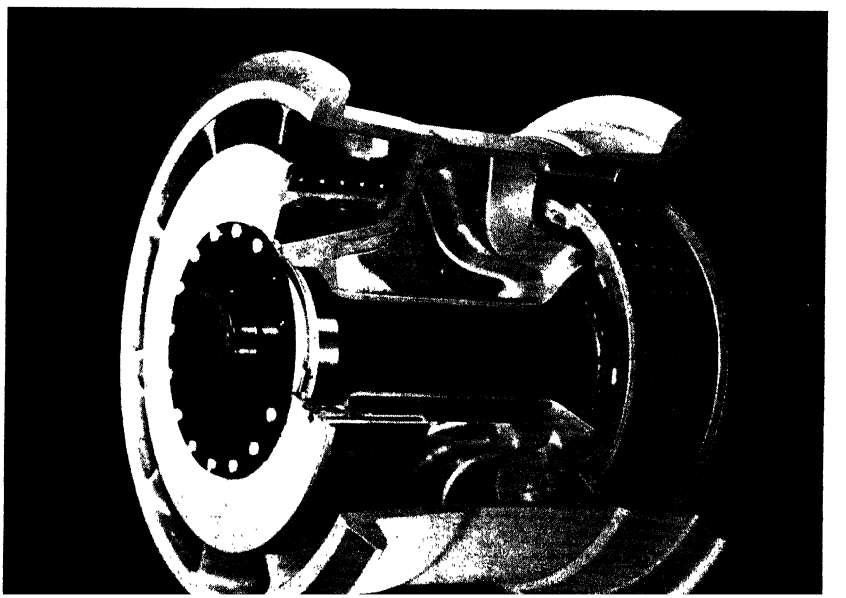
Other Dunlop employees who received well-deserved recognition for acts of gallantry and devotion were Miss Betty Quin, then acting as a nurse in the Welfare Department at Coventry, who was awarded the George Medal for rescue work during the Coventry blitz; Mr. Robert Porter of the Company's depot at Livery Street, Birmingham, and Mr. Eddie Rees, who was mentioned in the *Gazette* for bravery during the attacks on Liverpool, in May of 1941; while Major Monk, M.C., Employment Manager, Fort Dunlop, was awarded the O.B.E., for his work in connection with the Civil Defence and Fireguard Organizations of Birmingham, and Mr. J. W. Wood, then District Manager at Southampton, received the M.B.E., for personal bravery and excellent organizing administrative work as Chief Civil Defence Warden and Sub-Controller during the savage attacks on that town in 1942.

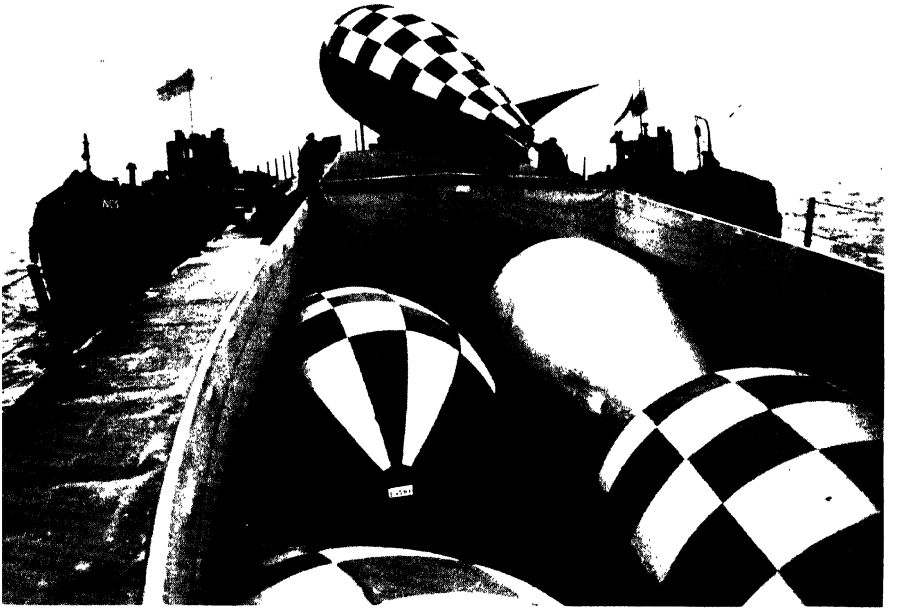
With the exception of the heavy damage inflicted by enemy air attacks on the Company's clothing factory at Edmonton (which I will describe separately), the main centres where large-scale Dunlop activities were concentrated and which were special enemy targets, were Birmingham and Coventry. Birmingham suffered repeated raids which did a good deal of damage, and it was inevitable that Fort Dunlop should have suffered also. During a raid in the North one of the factories making barrage balloons had 54,000 square feet of roof blown off. In one night the Footwear factory, the dock warehouse of the same division, and the latex storage tanks were all damaged by high explosives.

The flying bomb and rocket attacks on Southern England as the German fury of destruction reached its zenith, were the final test. Many Dunlop premises were damaged, but in spite of 199 "danger imminent" warnings in working hours, 284 alerts at night during the 80-day period of the V1 attacks, and the heavy and continuous threat of the V2's, every depot and factory in the area continued to operate.

Above: A bomb disposal squad in action at Fort Dunlop.
(See Chapter IX.)

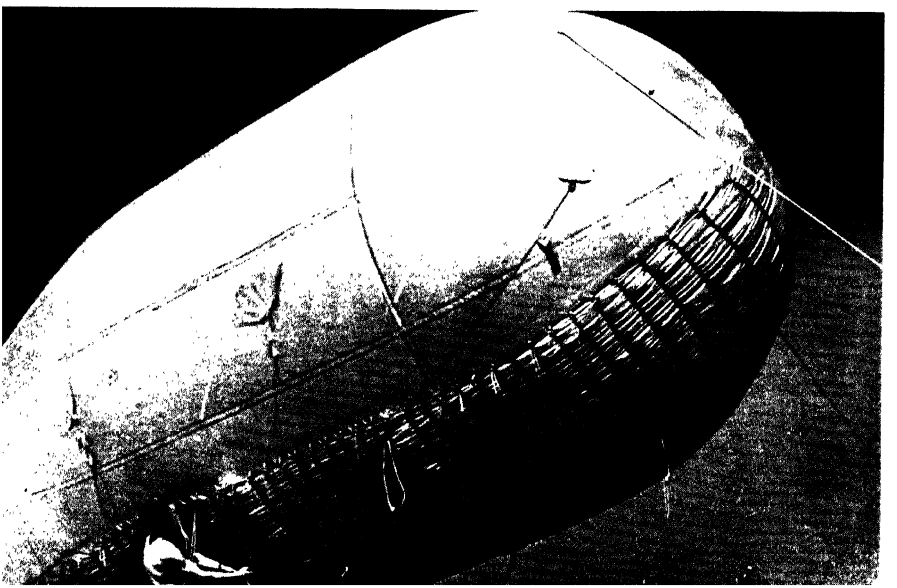
Below: A sectioned York wheel of which more than 2,000 have been produced for transport aircraft and some of the heavier R.A.F. bombers.
(See Chapter X.)





Above: Kite balloons go off to defend a convoy. The naval lighter alongside is ready to take one to its waiting ship. (See Chapter X.)

Below: An invasion balloon protects Salerno beaches.



FORT DUNLOP

At Fort Dunlop there were five occasions when casualties were caused. The earliest was on the night of 23rd-24th August, 1940, when bombs fell on the Wages Office, the Motor Cover Department and the Finishing Shop. In this raid the Company lost three workers killed and two seriously wounded. Although the Wages Office was practically demolished all the wages of the thousands of employees were paid on the next Friday as usual.

A raid which was almost miraculous in that no casualties occurred took place in the late afternoon of September 27th, 1940. The Germans dropped a 1,000-kg. bomb—the largest used up to that time against Birmingham—which fell just outside the fence beyond the machine tool department. It made a crater sixty-five feet in diameter and thirty-five feet deep. The debris from this caused considerable damage to adjoining roofs and the blast damaged brickwork, but no one was seriously injured. As the bomb dropped at 5.30 p.m., when hundreds of operatives were crowding roadways, this was a remarkable escape.

The raid on the night of 19th-20th November, 1940, caused one death and five injuries, one serious. Great heroism was shown by a number of the Company's workers in rescuing trapped fellow workers. In one incident it was known that an air-raid spotter had been on duty at the point at which a bomb had just fallen. Two operatives fought their way to this point and found the spotter injured. They administered first aid and carried him to a dressing station. On the same night four moulders and their foreman, after the fall of a bomb, left their shelter and re-entered the shop to ascertain whether any failure of services had occurred that was likely to damage the 600-odd covers which were in process of curing. The shop was in total darkness and loose debris was hanging dangerously from the roof, but they attended every machine, released the hydraulic pressure and so saved supplies desperately needed by the Forces.

There were three raids in which large quantities of incendiary bombs were dropped on Fort Dunlop. In one of them the brigade had to deal with eight serious fires at once, and they were all extinguished without outside assistance. This brigade consisted of ten mobile pumps with crews amounting to 100 men, in addition to 130 fire guards made up into stirrup pump and hose parties; and there was an emergency water supply of 2,000,000 gallons in tanks, 100,000 gallons per hour from private wells and a bulk supply available from the Corporation's sources.

Another incendiary raid took place on the night of 10th-11th April, following one of the raids described above. This time twenty-two workers were severely burnt. Serious damage was done on this occasion when the entire stock of uncured covers in one department was destroyed and the roof of the whole section burnt out. Employees climbed fearlessly about the roofs during this raid and extinguished many bombs which might have started serious fires.

The first occasion on which the Germans dropped explosive incendiary

bombs on Fort Dunlop was the night of 29th-30th July, 1942. Little material damage was done, but unfortunately the employees who dealt with these bombs were unaware of their new type and dangerous nature. The result was that two were killed and three injured.

There was never a second's hesitation amongst staff or operatives when air raid emergencies called for disciplined heroism. Everyone strove to protect his fellow workers, and the loss of life and property was infinitesimal compared with what it might have been in less capable hands.

In all these activities the Home Guard co-operated closely with the A.R.P. and Fire-Fighting Services. No unit of Britain's home defence during the war had a more important part to play or plant to protect, and none was more quickly formed or steadily supported than the Home Guard at Fort Dunlop. On 16th May, 1940, only two days after Mr. Eden had made his famous broadcast calling all Britons, and especially those with military experience, to the watch on the home front, the first enlistment of 230 men took place. This group, at first so unimaginatively called the Local Defence Volunteers, contained many men who had seen service in the first world war and others who had had Army experience between the wars.

While the fears then current were fortunately not realized, it is easy to forget now that when the war broke out there were widespread apprehensions of sabotage. No one could be sure to what an extent the Germans, intent for years on the war they finally launched, had perfected plans for destroying British industry from within. Loyalty was therefore the first of all requisites, and an abundance of it was forthcoming at Fort Dunlop. It was then that the Company's long-established policy of employing ex-Service men was seen to have been not only patriotic and just, but also far-sighted.

The L.D.V. was truly democratic. A man's work and position in the factory were no index to his rank. Military experience, ability and enthusiasm were the deciding factors. At first, as elsewhere, there were no uniforms and hardly any armament. The Company purchased twelve shotguns and these, together with a miscellaneous assortment of first world war souvenirs, sporting guns and revolvers formed the original equipment. Luckily there was already a very strong and well-equipped miniature rifle club at Fort Dunlop. Its rifles, ammunition, target and range were immediately taken over and thus the L.D.V. got off to a good start. When the War Office appointed a Chief Organizer, Colonel Woods, for Birmingham Factory Units, he sent for the officer in charge of the Dunlop unit, and said: "However much the Dunlop Rubber Company would like to pay you, and however much they are already paying the A.R.P. and A.F.S. men, they must not pay your chaps one penny; no one in England can run a private army." Thus stimulated the unit's strength grew to 450 men, with Major H. H. Lawley, M.C. (Garage and Test Fleet Superintendent) and Major A. R. Bloxham (Production Manager in the Lastex Yarn and Lactron Thread Department) succes-

sively as Company Commanders and Major W. N. Doley, (Dunlop Representative in Belgium) as second in command of the battalion in which the Fort Dunlop Unit provided Headquarters and "A" Companies.

Shift arrangements caused many complications for watch and ward, and it was clear from the start that men working all day could do all-night duty only one night in fourteen. The week-end groups were—in a fine spontaneous gesture—made up entirely of staff men, so that the factory employees could have their week-ends for rest and recreation. Altogether there were fourteen guard groups, formed as far as possible of men who knew each other, so that in the dark or in a mêlée recognition would be easier. The first armed guard was mounted on 4th July, 1940. In due course the unromantic L.D.V. was renamed, inspiringly, Home Guard. Raids continued at frequent intervals and as the methods of the enemy changed the Home Guard training changed to meet them. The men lived under extremely difficult conditions, with long hours of duty often endured after tiring work on essential rush war orders.

Interspersed with these were other varied activities. The Dunlop Home Guard more than held its own in a number of shooting and other competitions with other Home Guard detachments and with units of the regular Forces. Nor were lighter aspects lacking. Every orderly officer on duty made out a report of the day's events in a log book provided for the purpose. The following is an extract from the report for 7th December, 1941, the day of Pearl Harbour, by Lieut. C. L. Bostock:

> "21.00 hours; B.B.C. announced hostile acts by Japan. Guard turned out as a purely precautionary measure. All aid offered to the U.S.A. Troops warned of the dangers of fraternizing with Geisha girls.
>
> "09.00 hours: Handed over the care of a troublesome world to Lieut. A. G. Perret, whom God preserve."

Altogether more than 1,100 Dunlop men joined the Home Guard from start to finish. In addition a few joined other units nearer their homes. Thus for almost five years a group of voluntary, unpaid, hard-working men gave their time and risked their lives in a patriotic contribution to the war effort of the utmost value. Had it not been for the sacrifices they made to keep the factories in active production many lives might have been lost on the other fighting fronts for lack of supplies. These men have earned the pride they may well feel in their double contribution to the War.

Coventry

The experience of Coventry in the war was such that it became a symbol of the war effort, the unsuccessful attempt of the Germans even giving the language a new verb: "to coventrate" a thing is now understood as an unsuccessful attempt to destroy it.

The organization in Coventry was represented by the Dunlop Rim

and Wheel Co., and the grim wartime experiences of its A.R.P. measures and its Home Guard make them worthy of a special mention. The training of the workers in A.R.P. began at Coventry in 1937, long before most industrial firms had begun to take action against the possible consequences of an enemy attack on Great Britain. By the end of 1938 the formation of the A.R.P. organization was practically completed, a fire brigade had been organized, lectures had been given to all senior employees, and a fully qualified nurse had been engaged for a special ambulance room to deal with casualties. During 1939, the A.R.P. programme was sharply accelerated. Construction was started on shelters and steel-lined trenches to accommodate 1,600 people; protective clothing for the fire brigade and respirators for the civil defence volunteers had been obtained; sandbags were prepared to protect the machinery in any emergency, and the old swimming bath was allocated for fire brigade use and kept filled with 100,000 gallons of water. Sites were chosen for six fire brigade posts in vital places and the strength of the fire brigade was increased to about fifty men. Drills were practised for quick evacuation to shelters, a system of air raid alarms was perfected well in advance of the national use of sirens, and provisional arrangements were made for quick blacking out if this should be decided upon. A full gas and decontamination squad was trained—so that when the war actually began every possible precaution had been taken.

In 1940 the wisdom of all these carefully planned arrangements began to be obvious. By October there were indications that the Germans were making a special effort to destroy Coventry with its all-important engineering works. Fairly heavy enemy attacks were made on the city on 21st, 22nd and 23rd October. Although their own premises were not damaged, Dunlop men and equipment were able to give sorely needed help to others who had been less fortunate.

The night of the 14th-15th November was the occasion of the historic raid on Coventry. Thirteen direct hits by high explosive bombs were suffered by Dunlop. Very serious damage was done to the factory, in which a night shift was working, but fortunately, though there were a few cases of shock, such effective protective steps had been taken that there were no serious casualties to workers.

On that occasion all present acted as a team in performing outstanding service. Workers on the night shift joined with the fire brigade and the A.R.P. workers and made herculean efforts to confine the fires and other damage as narrowly as possible.

The whole world knows what happened to Coventry that night, when the enemy fury did its utmost to destroy this vital centre of Britain's war effort, and when thousands of workers' homes as well as their places of employment were blasted into ruins. Perhaps the best answer of the Dunlop organization to Hitler was, that on the morning of the 15th, in spite of many home casualties and an utter lack of transport, 80 per cent of all employees, both staff and workers, reported for duty.

Under the leadership of the General Manager, Mr. J. Wright, all got to work in cleaning up the most atrocious picture of destruction any of those present had ever seen. Electricity, gas and water services were all out of commission. One of the first tasks of the Maintenance Department was the provision of a rudimentary catering service for the supply of hot soup and bread and cheese. Members of the staff turned themselves into sandwich men, carrying placards around announcing where food was to be found. Within four days a full midday meal was available, many women employees volunteering to help in getting it ready.

In view of the almost complete breakdown of ordinary facilities in the city, the factory officials were glad to obtain the co-operation of Messrs. Marks and Spencer, who set up a food stall in the canteen where employees were able to do their most urgent shopping.

Within four days after the raid twenty per cent production had been resumed and within five days a day and night shift was operating. At the end of some four weeks, both production and labour attendance were about normal. Hermann Goering, whose arrogant testimony at Nuremberg has described how he sent the Luftwaffe against Coventry, had miscalculated the calibre of the people against whom he launched his weapons.

DUNLOP AND THE A.T.C.

Dunlop's close association with the R.A.F. made it natural that the Company should take an interest in the A.T.C., and although the A.T.C. was not, like the Home Guard, a defensive organization, I think I can appropriately give at this point a short sketch of the Company's contribution to what proved a most valuable training ground for the Air Force.

The Dunlop A.T.C. squadron made a brilliant record in the war, partly because it was so early in the field. Its history really began in August 1939, about eighteen months before the official A.T.C. was formed, when the Company received and accepted an invitation to sponsor a squadron of the Air Defence Cadet Corps, which had been formed under the auspices of the Air League. The change-over took place early in 1941.

The serial number allocated to the Dunlop squadron of the A.D.C.C., was 165, indicating its early formation, and this number was kept throughout its history. During its four years of existence the Fort Dunlop squadron achieved distinction after distinction, eventually becoming, in July 1944, the champion squadron of the Birmingham Wing.

The utmost help was given by the Company to the squadron and a large number of officials from the Chairman downwards afforded active, continuous and practical support. The constitution of the A.T.C. required that each squadron's affairs be administered by a civilian committee, which supervised the spending of money advanced by the Air Ministry at six-monthly intervals. No public money was spent for welfare purposes and it fell to the committee to raise the needed funds, make sure that adequate welfare facilities were provided, and account for the money.

Mr. H. L. Kenward, at that time Director, General Sales Division, undertook the Chairmanship of the Fort Dunlop squadron and served until April 1945, when pressure of other work forced him to give it up. It was taken over by Mr. A. Healey, the Director of Production, who had been one of the original members of the Committee.

The normal establishment of the squadron was eight officers and two warrant officers. Throughout the squadron's life, seven of the eight officers and both warrant officers were men in the employment of the Company at Fort Dunlop.

One factor which greatly contributed to its remarkable efficiency was that the Company could and did supply excellent civilian instructors. Not all A.T.C. training was carried out on the parade ground or the aerodrome. Much time was spent on the theoretical side and in the class-room, where instruction was given in mathematics, English, navigation, aircraft recognition, Morse code, engineering, etc. The A.T.C. had to rely on civilian instruction in much of this work, and at Fort Dunlop the great resources of the technical, engineering and other specialist departments could be drawn upon. At one time more than thirty highly qualified experts were voluntarily giving up one or two nights a week to provide the best possible instruction for the cadets. Many of these had previous teaching experience and seventeen were University graduates.

With this strong background and with the excellent premises provided by the Company, it was natural that the squadron should be an outstanding success. Amongst many items of interest one of the most striking was the ceremonial parade held on the Fort Dunlop Playing Fields on 6th June, 1943, at which Sir George Beharrell, D.S.O., the Chairman of the Company, presented colours to the squadron.

The crowning achievement of the squadron was the winning, in July 1944, of the James Leek Trophy, a cup awarded annually to the most efficient of the thirty-one squadrons of the Birmingham Wing.

In common with all other A.T.C. squadrons, the Fort Dunlop A.T.C. suffered severely from the change of Air Ministry policy at the end of 1944. The need for R.A.F. recruits was then seen to be considerably below what had been expected and many keen young men who had been through the intensive preparatory training of the A.T.C. found themselves directed into other branches of the Services.

The last occasion on which the Fort A.T.C. appeared in public was at a parade held at Castle Bromwich Aerodrome on 28th October, 1945, when the squadron was formally amalgamated with two other neighbouring squadrons, which were in similar difficulties. In its four years of existence the squadron passed more than 250 keen and highly trained young men into the Royal Air Force, where many of them distinguished themselves and all were a credit to their Dunlop traditions.

CHAPTER X

DUNLOP'S WAR EFFORT

(*i*) AIR

I HAVE briefly described the technical and administrative difficulties with which the Company had to deal during the war period, and the steps which it took for defence against enemy action of a type unparalleled in history. How successfully these problems and difficulties were overcome will be seen from my next few chapters which deal with the many, various and often amazing products contributed by Dunlop to the Allied war effort.

The products briefly described came from the following thirty-two factories of the Dunlop Group of Companies in Great Britain and Northern Ireland:—

Belfast	Tyres, etc.
Birmingham, Fort Dunlop	Tyres, etc.
Tyseley	Wheels, Aircraft Products
Black Bank	Aircraft Products
Coalville	Aircraft Products
Coventry	Wheels, Aircraft Products
Dudley	Wheels, Aircraft Products
Edmonton	Clothing
Exhall	Aircraft Products
Glasgow, Inchinnan and Thornliebank	Tyres, etc.
Kelvin Hall	Balloons, Dinghies, etc.
Hampton-in-Arden	Aircraft Products
Hinckley	Aircraft Products
Hugglescote	Aircraft Products
Kingsclere	"Semtex" decking for ships, etc.
Leicester	Tyres, etc.
Liverpool	Footwear
London (Earl's Court)	Balloon Parts
Longshoot	Aircraft Products
Manchester, Brook Street	Footwear
Cambridge Street	General Rubber Goods
City Hall	Balloons, Dinghies
Gaythorn	Balloons, Dinghies
Hulme Street	Balloons, Dinghies
Trafford Park	Balloons, Dinghies

Melling	Balloons, Dinghies
Reading	"Semtex" decking for ships, etc.
Rhodes	Balloons, Dinghies, etc.
Rochdale	Cotton fabrics
Stoke-on-Trent	Tyres, etc.
Waltham Abbey	Timber Products

It is perhaps most convenient to classify the chief Dunlop contributions to the war effort in accordance with the field of operations for which they were devised—air, land and sea. As the Company's services to the war in the air were of such outstanding importance, I will describe them first:

Tyres, Wheels and Brakes

Ever since the first air raids in the 1914 war, it had been common knowledge that the Air Force, far from being a mere accessory of the Army and the Navy, would play at least an equal part both in defence and offence: that the very existence of the two senior forces would be gravely jeopardized without adequate air cover. Hence the need for a rapid war expansion of the Air Force out of all comparison with its former strength.

Aircraft run on rubber tyres, just as truly as do the mechanized vehicles of the Army. Their variety, and the problems which have to be solved in manufacturing them, confronted Dunlop with a situation which taxed the energy, inventiveness and improvisation even of the acknowledged leaders of the tyre industry, for the greater part of aircraft tyre production throughout fell upon Dunlop. The Company was responsible for designing suitable tyres for war-time aircraft in conjunction with aircraft manufacturers and for securing approval of the Ministry; also for the dissemination of information in regard to design and servicing to the rest of the tyre industry. Mr. H. E. Price was Dunlop's responsible contact official in connection with this important work. To meet the unprecedented emergency, the Company harnessed all available capacity for making aeroplane tyres in every suitable factory they possessed. Everything had to be done at once, while the Air Force was calling for more and always more tyres. To illustrate the difficulties involved, a typical bomber tyre weighed seventeen times as much as the ordinary motor-car tyre and the labour needed to make it was forty-five times as great. The range of tyres produced for aircraft was most comprehensive and covered not only the types required for the R.A.F. but also the main sizes used on American machines. The largest British tyre on operational aircraft was the main landing wheel of the Stirling, the over-all measurements of which were 72½ inches diameter by 28¾ width; the smallest, for the tail wheel of the Spitfire, measured 10½ by 3½ inches. On American aircraft the largest tyre was 58 by 20½ inches for the main landing wheel of the Fortress, and the smallest 8¼ by 3¼ inches for the tail wheel of the Martlett.

Space does not allow me to give details of all the many varying types but two special types deserve separate mention.

Aero Tail Twin Contact Tyre

The *Aero Tail Twin Contact Tyre*, was the invention of Major O. J. Marstrand, of the Royal Aircraft Establishment, Farnborough, and was developed at Fort Dunlop. It has only two heavy tread ridges in contact with the ground and these stop the violent side-to-side (shimmy) movement of the aeroplane tail wheel, when taking off or landing, which may cause serious damage to the plane structure. "Shimmy" may wear out the treads in a few landings; this twin-contact tyre lasts hundreds of landings and greatly reduces the man-hours required in maintenance.

Ecta Tyre

The *Ecta Tyre* is one of the great advances in aviation. It is a tyre which conducts electricity, and all aeroplane tail wheels are now equipped with it. It avoids the danger of fire from static electricity, which may accumulate on the surface of a plane up to 500,000 volts and give off, when the plane is refuelling on the ground, a spark that might set the petrol alight.

To avoid the grave risk of fire or shock, it is necessary for an aircraft to be electrically earthed immediately it touches the ground. Ordinary rubber tyres act as insulators; but Dunlop was the first to make aero tyres from a rubber compound having the unique property of conducting electricity and yet retaining the necessary normal qualities of flexibility and toughness. When these tyres touch the ground they provide the simplest and most direct earthing device; they will discharge the static electricity from an aircraft in 1-10,000th of a second and make unnecessary the use of a trailed earthing wire.

Since aeroplane tyres, wheels, brake drums, brake units and brake controls are really one complete part of an aeroplane's mechanism and must work in absolute unison if the highest efficiency is to be obtained, it is highly desirable that the entire mechanism should be made by one firm. Dunlop has made a great contribution to the high performance of British aeroplanes, because their mechanism is designed as one unit, always with due regard to the distinct requirements of each component of the complete assembly.

In the United States aeroplane industry, on the other hand, separate designers and manufacturers are usually responsible for the various items. The disadvantage of this arrangement is that unduly hard brakes are sometimes used, and cause the tyres to wear out rapidly. The same defect has been observed in the painfully audacious New York taxicab.

Dunlop's long experience of wheel construction was of inestimable value in the development of aeroplane wheels and brakes, and very

rapid progress was made in this field during the war. This work and the development of the gun firing mechanism, which I shall mention later, were carried out by the Dunlop Rim and Wheel Company at their factories at Coventry and Dudley under the management of Mr. Joseph Wright. The inventive ability of Mr. Trevaskis, the chief designer of the Company, proved of outstanding value in this very important task.

The average person, seeing an aeroplane gracefully landing at an airport and rolling smoothly over the ground to its appointed terminus, has little idea of the engineering and technical problems that have had to be overcome before that aeroplane could land at all without disagreeably shocking its passengers, and then be stopped at the desired point. Everyone is familiar with the importance of motor car and lorry brakes, but they seldom realize that the aeroplane brake presents problems far more difficult than those met in the construction of adequate brakes for motor vehicles.

Braking creates heat almost faster than any other known process—unless it be an atom bomb. For instance, a fighter aeroplane weighing 11,000 lb. landing at 60 miles per hour, creates a rise of temperature in the braking drums of 750 degrees Fahrenheit. A lorry of the same weight, pulling up at 40 miles per hour, and with brake drums more than twice as heavy as those of the aeroplane, will only raise the temperature in the drums by 95 degrees.

Thus the manufacturing of aeroplane wheels, tyres and brakes is an extremely complex matter, particularly as it is imperative to keep weight down and to obtain the maximum of performance from equipment that must take up as little space (and weight) as possible.

Every aeroplane designer spends much of his time and energy in a ceaseless endeavour to reduce the weight of the complete aeroplane structure. The temptation to seize on the wheel as a component which should be reduced to an absolute minimum is great, since the wheel in no way contributes to the strength or the performance of the plane when in flight.

On the other hand, the brake designer is continually being set to meet more severe conditions, inevitably resulting in a tendency to increase weight. The close attention to the aeroplane wheel in recent years has, however, resulted in so great an advance in technique as more than to offset any tendency to overload the brakes. In the modern aeroplane, with its high landing speed and retractable tricycle undercarriage, it becomes increasingly difficult to provide a wheel which:

(a) is of the smallest overall dimensions;
(b) will spread the load to be carried over a sufficiently large area to avoid destruction or rapid wear of the landing surface; and
(c) possesses brake capacity powerful enough to arrest the aeroplane on landing and to manœuvre on the ground while taxi-ing.

To increase performance and bomb-carrying capacity, wing loadings have increased, and landing speeds have increased correspondingly.

These increases have meant that as between the aeroplane of 1939 and 1944, a four-fold increase occurred in energy which has to be dissipated as heat.

One great advance which has been made in the manufacture of aeroplane tyres and wheels is the reduction of their size by higher air pressures. Dunlop have been faced with a hard problem in the necessity of providing wheels which will enable the aeroplane to operate on a variety of landing surfaces, ranging from re-inforced concrete to grass, sand, and other types of soft terrain. The size of the tyre has been determined by the contact pressure which its landing surface will withstand without bogging the aeroplane.

In the almost entire absence of runways in the period prior to 1939, the inflation pressure of Service aeroplane tyres was limited to 35 lb. per square inch. With this pressure it has been found possible to operate from all but the softest aerodromes. Tyre pressures of 70 lb. per square inch are now frequently used with prepared runways, and a few new tyres have pressures as high as 90 lb. per square inch. According to information given by Mr. J. Wright, in an address to the Royal Aeronautical Society, pressures much higher than this are being tested experimentally.

These higher pressures, as Dunlop makes steady progress in increasing them, will benefit the aircraft designer in arranging for the retraction of the wheels when in the air. For an aircraft weighing 40,000 lb., the saving in weight by increasing the tyre inflation pressure from 35 to 90 lb. per square inch is as much as 500 lb. Thus the use of high pressure tyres in civil aircraft means a substantial increase in pay load, so that the equipment will pay for itself many times over.

All Dunlop aeroplane wheels are made from magnesium alloy castings which the Company initiated and developed. The low specific gravity of magnesium permits the production of robust castings of light weight. The comparatively simple design of the Company's wheel, born of co-operation with the foundry, has resulted in the production not only of very large quantities, but of uniformly sound magnesium castings, which have given exemplary service under arduous conditions.

General soundness of castings is considered of such paramount importance that, besides the usual routine chemical and physical tests, Dunlop carries out a percentage break-up test on all wheel and brake castings. This means that a certain number of every run of castings are destroyed to make sure the others are sound. This test is made by carefully smashing the finished heat-treated casting under a hydraulic press, and examining each fracture. It is a feature of this aluminium alloy that fractured areas show up coloured, and are therefore easily detected. After experience in particular foundries, it is possible to judge the deterioration in physical properties by a particular colour of the fracture: a pale yellow fracture, for example, generally means but little loss of

strength, whereas a grey fracture may result in a loss of as much as 60 per cent.

Whilst X-ray examination has been carefully explored, Dunlop has found this to be an impracticable method for examination of the complete wheel casting, although it is occasionally used to check a particular region which may be suspect and accessible.

The aeroplane wheel brake has to perform two main duties. Firstly, to arrest the aeroplane on landing, and, secondly, to steer it along the ground. Both these requirements are becoming more exacting with the considerable increases in landing speeds and weights, together with the reduction in the aerodynamic drag of the latest aeroplane types.

In considering the performance of an aeroplane brake it is instructive to compare its duties with those of the brake fitted to a heavy road vehicle.

When brakes were first introduced it was usual to adopt the conventional rigid shoe design commonly used for road transport work. As the duties of the aeroplane brake have become more severe the inflated bag tyre has come into general use.

The principal advantages of this type of brake are:

(a) That the distortion of the brake drum caused by the high operating temperatures can be accommodated by the flexing of the expanding sac.

(b) That the contact area between the brake lining material and the brake drum is spread to a maximum.

Some difficulty has been experienced in providing a brake lining which will stand the high temperatures of the brake drum, particularly when the brakes are used for prolonged taxi-ing to dispersal points, or for repeated landings, during instructional training. Much research has already been carried out, and is still being continued, with a view to providing improved brake lining; but the modern lining is a remarkable material and maintains its effectiveness even when the brake drum is red hot.

Some divergency of opinion appears to exist as to the rate at which an aeroplane is required to stop. It is most undesirable that, except perhaps in an emergency, it should be possible for the pilot to lock the wheel on the runway. When this is done, the rate of wear of the tyre tread at high speed is most serious.

The inflated bag type of brake is operated by compressed air or hydraulic pressure. From the brake operation point of view Dunlop prefers compressed air, which reduces to a minimum lag in applying and releasing the brakes and largely eliminates vibration, which can be extremely troublesome with hydraulic brakes.

Large Bomber and Civil Aircraft Wheel

One type of wheel which deserves special mention is that produced for transport aircraft and for some types of the heavier R.A.F. bombers. Cooling space has been introduced between the brake drum liner and the hub castings; and easy access to all component parts is a very noticeable feature. This is entirely a Dunlop development and the trend of post-war aircraft design suggests that it will have increasing value.

Seventy-one types of British aircraft are fitted with Dunlop tyres, wheels and brakes. For experimental purposes the Coventry factory had the use of a Wellington from the R.A.F.

Balloons and Dinghies

Throughout the war the most constant and visible (and now memorable) form of defence from attacks by hostile aircraft was the barrage balloon. These great grim war-fish, nervously tugging at the cables which held them as they swayed and adjusted themselves to the air currents, also played an important part in preserving civilian morale, especially in London. When the sun was reflected from their silver sides, the effect was of almost celestial beauty.

These monsters of the air, understandably dreaded by the German pilots, were mainly a Dunlop contribution to the nation's air defence. In 1936, when the total output of balloons in the United Kingdom was a mere two per week of Mark VII (the large type balloon used for the protection of towns and cities), the Ministry of Aircraft Production asked that methods of manufacture be developed capable of producing large quantities of balloons in a comparatively short period so that if war came thousands could be flown throughout the country at one time.

Dunlop's Balloon Division under the management of Mr. C. Hemm produced more than 28,000 balloons. During the flying bomb attacks, most of the balloons in the London area were moved to the South-East coast, where more than 2,000 of them have flown together.

Before Dunlop began balloon production on a large scale, nearly all the work had to be carried out on floors unencumbered by supports, since these would have broken up the great open spaces necessary for the acres of sheeting. The floors became in fact the workbenches of the operatives. Within eighteen months this method of manufacture had been abandoned, and the floor space needed for balloon manufacture was cut down by nine-tenths. No longer did operatives work kneeling on the floor. New methods were introduced by mass cutting into panels, "lays"—layers—of balloon fabric; and smooth buffing was used to remove the aluminium edge from the fabric and thus ease the joining together of panels. These new methods had the great advantage that they allowed the use of buildings which were quickly available, and obviated the construction of huge special hangars.

A further important advance was the multiplication of jigs in both metal and wood and of varied design. By the use of these jigs inexperienced

operatives quickly became skilled. As a single balloon of the largest type comprised no fewer than 1,592 components, this method eased production, and quite soon accessories for the assembly of balloons were mass manufactured. When production began, each balloon took 3,500 man-hours to make; before long it took no more than 500.

One result of this rapid development of balloon assembly was, that the Ministry of Aircraft Production were faced with the necessity of opening large factories to produce the rubber-proofed material required to meet the output, not only from Dunlop units but also from the assembly units of other companies. The first spreading factory installed covered an area of about 100,000 square feet, and the empty building taken over was converted into a spreading plant of seventy-five machines within three and a half months. Rubber mixing plant, wet-mixing plant, doubling machines, steam vulcanizing pans and printing machines had to be installed. It was also necessary to build a new boilerhouse containing four standard Lancashire boilers. The factory therefore was a self-contained unit having all the plant required for the process of rubber-proofing of dry cloth.

These spreading operations, particularly the wet-mixing, require a large volume of petroleum spirit solvent of a special type; here Dunlop had to make a difficult and important decision. On the one hand they considered that a complete naphtha[1] recovery system was essential. Against this, the plant for such a system was costly and they knew that if the war were of short duration there could be no due financial return from so great an expenditure. On the other hand, this petroleum solvent was a serious item in the national war effort, and, as it had to be imported, every gallon extracted by a recovery system would save vital shipping space. They therefore decided that the plant should be installed, and it proved a great success. Later on, similar recovery systems were installed in further spreading factories opened by Dunlop as the war progressed.

It was in the proofing factory just described that women operatives were first employed on spreading machines; after a suitable period of training they were found to produce as good proofing as the men.

This factory was in a most vulnerable area and operated day and night seven days a week. It was here during the heavy air-raid period at the end of 1940 and the beginning of 1941 that the operatives were the first to carry on during alerts, roof-watching having been introduced. In appreciation of the bravery shown by these operatives throughout this tense period, the following letter was sent to them by Lord Beaverbrook, then Minister of Aircraft Production:—

"By staying at their tasks after the air raid warning has sounded, the girls on balloon work at your factory are setting a magnificent example to all who are engaged on work of national importance and they are showing a high sense of public duty which is enabling them to render our country vital service.

[1] *Naft* is the Persian for petroleum.

"Will you tell them that their action commands my gratitude and admiration and that they have qualified as front line soldiers in the fight for freedom.
(Signed) BEAVERBROOK"

But it was not only thus that the operatives at this factory distinguished themselves. They had had only one day's holiday since the opening of the unit six months previously. Just as they were breaking up for three days' rest at Whitsuntide, an urgent request was received for a large proofing order to be completed within four days. The material was required for the manufacture of "K" type[1] dinghies for fighter pilots. This type of dinghy had only been developed during the three weeks prior to this sudden order. Until this time dinghies had not been included in the equipment issued to fighter pilots, and, in view of the urgent need, the operatives were asked to forgo their holiday. Only 2 per cent out of the whole number employed did not agree; and this vast majority carried on throughout the holiday period, so that within the time specified by the Ministry of Aircraft Production all the material required was delivered.

Proofing was now of such paramount importance that the Organization had intended to make considerable extensions to this factory. However, the buildings which were to have been extended were so badly damaged by enemy action that it was decided to transfer the proposed extension to a safer area. Suitable premises were found and in this unit they installed sixty spreading machines. In due time the factory was producing balloon and dinghy material in large quantities.

Meanwhile a further proofing factory had been opened in the Lancashire area and with the completion of a large factory in Scotland, Dunlop had, early in 1941, factories for the rubber proofing of dry cloth and the assembly and testing of balloons and dinghies with a total floor space of more than 750,000 square feet. The maximum was reached in May 1941, when some 6,000 people were employed in these units, and a Mark VII balloon was being completed every eighteen minutes of the day and night. More than 65,000,000 yards of dry cloth were proofed in these factories—mainly of highest grade Sea Island and selected Sudan cotton fabrics.

Even now this account of barrage balloons is incomplete. When Japan attacked the United States at Pearl Harbour in December 1941, the Americans had no balloon defences against aircraft attack. More than 4,000 British barrage balloons were sent to the United States by Great Britain, mostly to the Pacific Coast and the Panama Canal, where they formed part of the defences of shipyards, naval establishments and other war centres. Two thousand four hundred of these were made by Dunlop.

Besides the large type of barrage balloon familiar to everyone during the war, Dunlop produced three other types: (1) the *naval kite balloon*, for the protection of convoys; (2) a smaller type for the protection of

[1] V. Ch. XI end of para. 1.

beaches; (3) a balloon used for taking up the fuselage for training parachutists—at the stage between jumping from a wall and jumping from a plane.

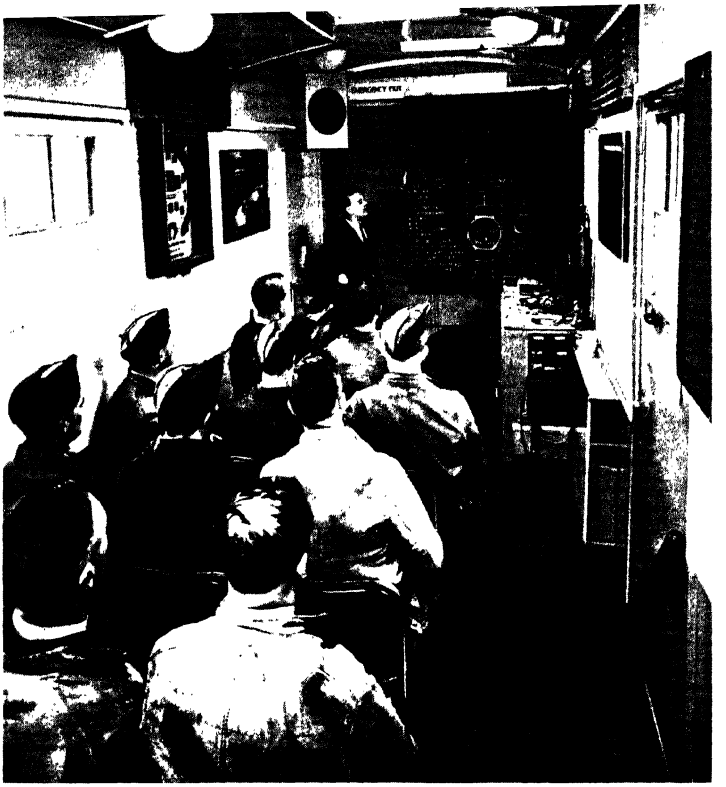
In addition there were the very important *Meteorological Balloons*. These were produced at the rate of 6,000 a week by a process developed by Dunlop and were of the greatest value to the R.A.F. and Allied Air Forces. They were sent up as high as 30,000 feet to determine the direction and velocity of the wind, and were the means of securing information which was vital before large-scale bombing attacks could be planned, especially where the destination of the aircraft was a distant one.

Finally I must mention the *Leaflet-Dropping Balloon and Release Mechanism*. This interesting device was a cause of great mystification and worry to the German General Staff. For a long time they were puzzled and unable to understand how the R.A.F. was able to drop leaflets over wide areas of German and occupied territory when no aeroplane had been detected by the most elaborate hearing devices. The secret was a balloon 15 feet in diameter from which bunches of leaflets were released by means of a fuse burning at the rate of 1 inch in 6 minutes. The fuse could be set to last up to 8 hours and to drop leaflets at intervals over a wide area, after which the balloon finally exploded, leaving little or no trace.

Akin to the balloon were the *lifting bags* which were used during the war for raising crashed aircraft from shallow waters. This type of bag was also used for small rescue craft which had been sunk. This ingenious device was more fully developed in Australia and I will describe it in the section on "Camels" when dealing with the contribution to the war effort of the Australian Dunlop Company.

As with balloons, so with the *dinghies*, which saved the lives of thousands of airmen shot down into the sea. With the mass production of fighter aircraft, and even more so with the increasing size and crews of bombers, it became necessary that suitable dinghies should be available for every type of R.A.F. machine. Before the "K" dinghy already mentioned had been developed, the fighter pilot, when baling out and landing in the sea, had only his "Mae West" to keep him afloat while he waited and hoped for rescue. The provision of dinghies added confidence to the pilot's mere hope, and the proportion of those saved after baling out rose rapidly. The Channel and the defence of Malta were the scenes of their greatest usefulness.

After the design of the dinghy had been perfected, the Ministry of Aircraft Production placed dinghies on the highest possible priority, and Dunlop turned out the rubberized material for the first bulk production. At the same time they manufactured templates, jigs and assembly units for seven other firms and delivered them within a week. Before making delivery of these items, a demonstration lasting two days was given to foremen and senior workpeople from these firms, showing them how to



TYRE CONSERVATION AND MAINTENANCE TRAINING FOR THE R.A.F.
(See Chapter X.)

Above: Interior of the Dunlop Travelling School, which was sent round to aerodromes.

Below: Practical instruction to R.A.F. trainees at Fort Dunlop. A section of the tyre-fitting bay.

A pastel drawing by Sir Muirhead Bone, the famous war artist, showing rigging and testing of balloons at the Dunlop/M.A.P. factory at Gaythorn, Manchester, which handled about one-third of the defence balloon output of this country.

[Presented by Dunlop to Manchester Art Galle

apply Dunlop methods in their own plants. Within a further week, each of these manufacturers had submitted his first sample for official approval, and within a month several thousands of dinghies had been supplied to fighter pilots. Altogether, Dunlop has supplied the Air Ministry with about 100,000 dinghies of all types for fighter and bomber aircraft.

These included the "J" type dinghies, made for bomber planes and weighing about 60 lb. They are inflated from a CO_2 bottle and with a bellows and carry seven men. They have been the means of saving thousands of airmen's lives throughout the war in all parts of the world. This type of dinghy is the one packed in the Lindholme Rescue Apparatus. The apparatus consists of five containers dropped to distressed crews from the bomb racks of searching aircraft. Four of the containers contain food, cigarettes, matches and other supplies to keep the airmen going until they can be picked up. The fifth contains the dinghy. When this container touches the water, the dinghy inside inflates and bursts open the casing, which floats away. The remaining four containers can then be hauled in by a buoyant line. The total weight of the Lindholme Rescue Apparatus is about 270 lb.

"K" is the fighter pilots' dinghy. When folded it fits into the pack, on which the pilot sits. It weighs about 20 lb. and is inflated by a CO_2 bottle, thus saving the airman the physical effort of inflating by bellows—a very real advantage for a wounded man.

"Q" is a sailing dinghy, fully rigged with mast, sails and rudder, for heavy bomber planes. Although it is 13 feet 6 inches long when inflated and is capable of holding seven men, it weighs only about 93 lb. and fits into a valise measuring about 26 inches long, 22 inches wide and 12 inches deep—the dimensions of a fair-sized suit case.

With dinghies I can appropriately mention the special *Lifebelt*, designed for airborne soldiers who might happen to alight on water. These provided adequate support in the water for a man and his equipment, including whatever arms and ammunition he would normally be carrying. A million of them were supplied during the war. I would cite also the *Water Cushion*, which serves as an emergency carrier of drinking water and was produced in co-operation with the R.A.F. Physiological Laboratory; and the *Rubber Seal* for the Airborne Lifeboat, a small but vital feature of the lifeboat carried by a rescue plane. The lifeboat is motor-driven and has enough petrol for 200 miles. When dropped by parachute into the sea the engine must be completely sealed. The rescued crew tear off the sealing tabs and remove the covering. The engine is primed and set to start up with one pull on the starting handle, so that, however exhausted the rescued men may be, they can start the engine without undue effort.

Franks Flying Suit

A milestone in the use of aircraft for military purposes was reached in November 1942, when the Allies landed at Oran, French North

Africa, and began the long, hard march which ultimately ended in the rout of the German armies on their home soil. It was in these Oran operations that the Fleet Air Arm first used equipment which staggered the enemy and left his fighter aircraft in a position of hopeless inferiority. The British pilots performed aerobatic feats which had long been deemed impossible without the pilots "blacking out," that is, without losing consciousness through the frightful strain on the human body entailed by pulling out of a dive rapidly or twisting and turning violently at high speeds. British pilots repeated their Oran feats—and on a greatly magnified scale—in the invasion of Normandy, and even caused German aircraft to crash to the ground when trying to follow or evade the manœuvres of the British machines. The secret of these dazzling performances which perplexed and confounded their German opponents, is bound up with the Franks flying suit (technically anti-"G" suits) and the story of the invention and eventual triumph of their suits forms one of the most dramatic chapters in the entire war effort.

Flying men have realized, ever since the early Schneider Trophy days, that the continuous improvement in the performance of fighter aircraft was bound to bring about a stage where any increase in high speed manœuvring of craft would be of little value if man, with his limited physical resistance to black-out, remained unprotected against the ever-increasing forces he would be called upon to meet. Aeronautical physiologists all over the world, therefore, had for a long time been concentrating on the problem of how to avoid the onslaught of black-out and unconsciousness, which had killed many experienced pilots (including world-famous aces), and to maintain pilots in full consciousness and vision whilst executing violent high-speed manœuvres.

The importance of this matter needed no emphasis, as it was clearly seen that protection against these forces, even if only in a small degree, would give opportunity in war to the side first protected.

The reason why British pilots could go through manœuvres which no enemy plane could follow was one of the best-kept secrets of the war, a great credit not only to the Service personnel who made the numerous and exhausting tests and carried out much intensive training, but also to the loyalty and utter abstention from careless talk on the part of the staff and operatives of the Dunlop organization concerned in making these achievements possible.

The many thousands of Franks flying suits which gave such a positive advantage to British pilots over the enemy were entirely manufactured at Dunlop's two Manchester factories.

As far as can be explained without technical and scientific language, it may be said that the object of the Franks flying suit is to prevent the downward rush of the blood from the head into the lower extremities of the pilot's body caused by centrifugal force set up during violent high-speed manœuvres, which robs the heart of its normal return supply of blood for redistribution over the body. This reduces the pressure in the

small capillaries at the back of the eye against the normal constant pressure within the eyeball, causing loss of vision—first a greying of the sight, then complete darkness or black-out. With this loss of vision goes loss of hearing; sometimes even loss of consciousness.

The principle of the Franks flying suit is to balance the greatly increased internal pressure in the pilot's body, caused by the downward rush of the blood, by applying an equal external pressure. This is automatically achieved by using fresh water, confined within the suit, as its density is nearly equal to that of blood.

The possibilities of the method were demonstrated on mice in Canada in 1939 by Dr. W. R. Franks (now Wing Commander Franks, O.B.E.), then doing medical research work at the University of Toronto. He early enlisted the co-operation of the Canadian Dunlop Company and in 1940 built the first suit, tailored to fit him with great accuracy. By the next year the general principles for its construction had been worked out and proved by test flights conducted by the R.A.F. experts at Farnborough and elsewhere. In September 1941 a secret development contract for a number of suits was placed by the Ministry of Aircraft Production with the Dunlop General Rubber Goods Division, at Manchester, and arrangements made for Service representatives, headed by Dr. Franks, then a Flight-Lieutenant, and Mr. J. B. Wilson, of the R.A.F. Physiological Laboratory, later F/O Wilson, to co-operate in carrying out the contract. On the Company's side, the supervision and development of this work was entrusted to Mr. W. G. Gorham, now Works Manager of Dunlop Special Products Limited. The Cambridge Street factory began immediately on the design and experimental production of a cloth to form the outer cover of the suit. It had to be strong, substantially unstretchable, light and flexible. Between them the Dunlop textile laboratory and their Cotton Mills at Rochdale produced this special material.

Sewn seams would not be strong enough, and it was found that a virgin rubber weld of pure latex was stronger after vulcanization than the original cloth. The bags for the water interlining of the suits were made with the complicated contour necessary to follow the curves of the human body, and were produced from virgin rubber. Manufacture of suitable boots, also with a water interlining, was successfully carried through, although eventually these were deemed unnecessary.

During the early months of 1942 there was much testing of the suit by the Service, resulting in frequent alterations, and the original three standard sizes were increased to seven to secure satisfactory fitting for every airman. The body measurements of no fewer than 750 members of air crews were taken to achieve this end (they tended to prove that Northerners have long bodies and short legs; Southerners the converse). When the first few hundred suits had been laboriously tested by actual trying on, the procedure was shortened by building inflatable men-like rubber forms on to which the suit was fitted. The form was then inflated and the rubber bag interlining filled.

Only a small volume of water—less than one gallon—is normally required to fill the suit when worn. Since the development contract was placed, more than 165 substantial changes have been made in design and construction, involving the working out of some 1,200 different patterns before the final range of 266 patterns was perfected.

The first work on these suits in its preliminary stages was performed by a small band of girls, not more than twenty in number. When the stage was set for quantity production these girls, who had become expert in every way, trained the new operatives.

Not only were the suits developed in Manchester but Dunlop was called upon for a host of accessories as well. All these were produced. They were mostly concerned with the charging and emptying of the suits, and with such things as filling bottles, electrically heated and thermostatically controlled reservoir tanks, and the like. Due attention had to be given to the problem of conservation of water used in the carrier-borne aircraft operations, and also in territory where water is a precious commodity, as well as ensuring that it is in a fit condition to drink in an emergency. The Franks suit was a contribution to the war effort of which everyone in the organization may well be proud.

Long before the war was over the factory was left with 2,000 suits on hand—because, as was said "The fighters can't find any Huns."

Aircraft Lifting Bag

Another most valuable device was the *Aircraft Lifting Bag*. This pneumatic bag, 7 cubic feet in size with a lifting capacity of 12 tons, can lift a four-engine bomber 4 feet from the runway in 8 minutes, thus allowing trolleys to be put into position beneath a damaged plane and the plane removed to make way for other aircraft about to land. Previously, hydraulic jacks took 4 hours to do the work. This appliance saved many lives when Allied aircraft returned damaged after heavy bombing raids with landing gear out of action and sometimes on fire. Often petrol supplies had become so short that a quick landing was imperative if the plane and crew were to be saved. In helping to clear runways, of which there were none too many for the largest sized bombers, this device proved one of the most successful of the war in the air.

Electric Pneumatic Firing System

One of the most important of all fighting developments for the air war, and one which was invented and worked out by Dunlop technicians, was the Gun-Firing System for Fighter aircraft, of which the total requirements of the Royal Air Force and the Fleet Air Arm were supplied from Coventry. Dunlop Gun-Firing mechanism was used by every fighter which took part in the "Battle of Britain."

Increased armament in fighter aircraft, combining cannon and Browning guns, made selective firing necessary. By pressing with his thumb the Dunlop selective gun-firing button in the control ring handle,

the pilot can use either his complete armament of cannon and Browning guns, or alternatively, any combination of armament he requires. An electric current is conducted to the electro-pneumatic firing valve, which allows air to pass through to the release operating mechanism on the guns. The action is almost instantaneous. The system was designed to minimize any possible time-lag between the pressing of the gun button and the firing of the guns. With the increased speed of fighter aircraft, any such time-lag might result in the overshooting of the target. This need for instantaneous firing was recognized in the very early days of the war, and the combination of air and electricity for the purpose was immediately developed. The electro-pneumatic installation is a product of Dunlop design and development throughout.

To conclude this summary of Dunlop's contributions of equipment to the air war, I will mention a number of items which, if space permitted, would well deserve more extended treatment. Of these the most important is the Self-Sealing Fuel Tank Covering.[1] Three-quarters of all aeroplane losses in the first World War were due to punctured fuel tanks. In the late war, also, this became quite a serious cause of loss. Dunlop developed special types of rubber and covered many thousands of fuel tanks, so that penetrations by enemy bullets were immediately sealed, thus saving fuel and reducing danger of fire. Millions of square yards of rubber were made for this purpose and large quantities were supplied to other coverers as well.

The Anti-icer prevents ice accretion on the wing edges and propellers of aircraft. In winter flying the prevention of ice is essential. This invention has greatly reduced the hazards of flying in cold weather or at great heights.

The inflatable "Stole" of the famous "Mae West" life-saving jacket, an essential part of the airman's equipment. Dunlop in the course of the war supplied over 167,000 of these.

The Terrain Map Model is an aerial relief map for briefing bomber crews in target topography. It is made in Dunlopillo cushioning and is therefore unbreakable, easily transportable, can be rolled up, and is of course very light in weight.

Parachutists' pads are used during parachute training and protect the heels, knees, spine and helmet of the trainee.

Rubber Anti-Vibration Mountings fit aircraft instrument panels. This is only one of thousands of instances where rubber will reduce noise and vibration, adding years of life to metal and other instruments and vehicles and their users.

Last, but by no means least, comes:

Mr. Churchill's Mattress, on which the Prime Minister slept when he made his famous flights to various international conferences. The mattress is made from the rubber cushioning (Dunlopillo) which besides

[1] *See page* 34.

inducing his essential slumbers, also eases the seating of London buses and of the Shakespeare Memorial Theatre at Stratford on Avon, and innumerable others.

Before passing on to deal with Dunlop's contributions to the war on land and sea, I will refer to a service which the Company rendered to the R.A.F. quite as important as the supplies of vital equipment which I have just described.

Tyre Maintenance Training for the Royal Air Force at Fort Dunlop

Early in the war it became evident that the maintenance of tyres on R.A.F. aeroplanes must be high priority in keeping the war in the air up to the highest effectiveness. The aircraft tyre, so vital to the successful prosecution of the conflict, had to work under extraordinarily arduous conditions. After the first few months of fighting in the air, it was clear to the Air Council that indifferent tyre maintenance was bringing disastrous results, and, to provide a remedy, they called in Dunlop.

In co-operation with the Air Ministry and the Technical Training Command of the Royal Air Force, there was provided at Fort Dunlop a fully equipped school devoted entirely to training airmen in the operation and maintenance of aircraft tyres. Tyre maintenance had always been included in R.A.F. training but not on anything like the scale which proved necessary in war, when many problems were met which it had been impossible to foresee in peacetime. Training at Fort Dunlop began with a modest intake of twelve trainees on a four days' course, but with the entrance of Japan into the war and the sudden acceleration of rubber conservation problems the size of the classes was increased, until in early 1943 more than forty trainees were passing through the school every week.

In 1943 instruction in the use and operation of the Dunlop "Spotter" rubber repair apparatus was started. Originally a separate course was given on this extremely useful (and easily portable) equipment; later, both maintenance and spotter courses were combined, with the result that at the end of the war the Company had some fifty trainees constantly under instruction.

The rapid expansion of this Dunlop activity (under the superintendence of Mr. E. Charlwood) during the dark days of the war, when heavy losses in aircraft necessitated the utmost conservation of all existing tyres and the salvage of all that could be preserved for further usefulness, was a heavy strain, for aeroplane tyre maintenance is a much more complicated subject than may be supposed. The tyre specialist on a station, if he is to justify the responsibility placed on him, must possess a working knowledge of tyre construction and appreciate the fundamentals of design and the functions of cover and tube. He must be able to recognize damage in degree and, most important, to identify the cause and suggest means for preventing a recurrence. Classes, and

therefore instructors and instructional equipment, had to be multiplied. The original band of technicians who had organized the courses became increasingly occupied with material and production problems. The consequent shortage of instructing staff was solved by drawing upon the Royal Air Force for resident Service instructors. After an initial period of training, these relieved the Dunlop civilian instructors of the bulk of the work.

This activity constitutes another notable general contribution to the war effort. Approximately 5,000 trainees passed through the school and upon each a report reached his Commanding Officer through Technical Training Command. While classes were mainly drawn from the R.A.F., men from Canadian, Czechoslovak, Norwegian, New Zealand, Australian, Dutch, Polish and United States units, as well as civilian fitters from R.A.F. maintenance establishments and a small number of W.A.A.F.s, also attended the school.

The training has resulted in a vastly improved standard of aircraft tyre maintenance on stations, producing higher service of aircraft with a remarkable saving in machines and so in lives. There was also an immense economy in time and labour through keeping in service tyres which previously would have been scrapped or unnecessarily returned to the factory.

Mr. Churchill proclaimed at the time America entered the war that the British and American war efforts "would be somewhat mixed up together." This was nowhere more true than in the sphere of aircraft tyre maintenance. Whilst the original courses were planned upon Dunlop Tyre design and procedure, it was soon found necessary to procure a complete range of American aircraft wheels and tyres to enable instruction to be given on the fitting and removal of such equipment during the training of U.S.A.A.F. maintenance crews and of R.A.F. men working on American machines.

CHAPTER XI

DUNLOP'S WAR EFFORT

(*ii*) LAND

TYRES

DUNLOP on Land suggests first and foremost tyres, and I will group all tyres together: including those for airborne motor cycles, ambulances, armoured cars, army lorries, bomb trolleys, Bren carriers, paratroops' folding bicycles, tanks, tractors, travelling wireless stations, water carts, and wireless hand carts. The number of tyres of all these types provided by Dunlop during the war was almost frightening and the supplies could not have been maintained without the most careful planning and allocation, covering both land and air. For this vital work Mr. T. H. Taylor, the Company's Supplies Manager, was chiefly responsible. I will only describe in detail a few of those which were of particular interest and value. Many of them were shewn at the exhibition of Dunlop's war products which was held at the rooms of the Royal Empire Society in July 1945.

SAND TYRE

The *Sand Tyre* took the Eighth Army across North Africa from Alamein to the moment when the Axis armies were driven into the sea. It was built from four-inch models, tested in trays of sand at Fort Dunlop after consultation with Miralai Hatton Bey, Officer Commanding the Camel Corps and Car Patrols of the Egyptian Frontiers Administration, who had asked Fort Dunlop for a tyre which "would be to the car what its broad-spreading feet are to the camel." The aim was a tyre in which ground pressure was reduced to a minimum, imitating as nearly as possible that of a camel's foot.

TANK TYRE

Before the war in Europe ended, the 1,000,000th *Tank Tyre* had been produced at Fort Dunlop. It is not generally appreciated by the public that tanks run on tyres. The largest British tank has twenty-four of them which, with their wheels, weigh thirty-four cwt. The control of the section of the tyre industry devoted to the production of these tyres was entrusted to Mr. P. A. Stoner of Dunlop's Equipment Division.

TRAKGRIP

The *Trakgrip* is supplied to the Army and the R.A.F. for use on both rough terrain and main roads. The rugged open tread of this design, originated by Dunlop in 1926, increases traction power.

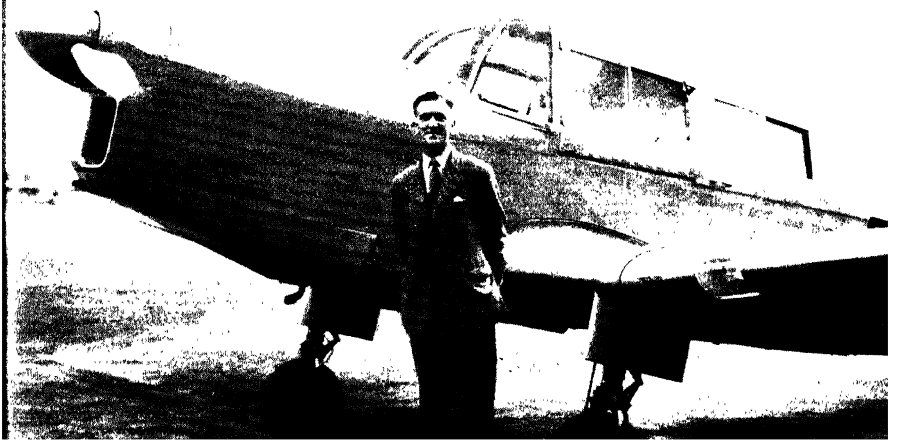
The compressed button of the Dunlop gun-firing mechanism fitted to control handle of plane. (See Chapter X.)

Photo : *Daily Exp*

Stirling bomber tyre and tail-wheel tyre. (See Chapter X.)

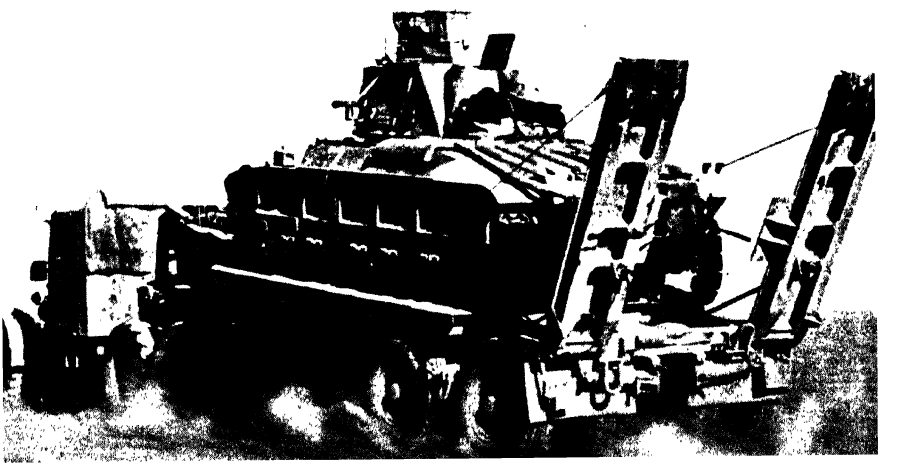
Above: A crashed bomber lifted by the pneumatic lifting bag, a seven-feet cube with lifting capacity of 12 tons. (See Chapter X.)

Below: The Dunlop Chief Test Pilot, Mr. W. H. Sutcliffe, with the "Proctor," the Aviation Division's communication aircraft.



Above: A rubber dinghy in use. When needed it is thrown out of the aircraft, the rip-cord pulled, and inflated from the gas bottle.
(See Chapter X.)

Below: TYRES FOR THE TROOPS: 1. For tanks and transporters.
(See Chapter XI.)



Airborne Motor Cycle

Then there is the *Airborne Motor Cycle*, the paratroop midget motor cycle, which, dropped in a bomb case by parachute, is equipped with Carrier tyres developed for the purpose.

Run Flat Tyre

As the name *Run Flat (Bullet-proof) Tyre* suggests, a bullet may penetrate this tyre, but there is no immediate deflation. When shot through it will continue to run at normal speed for at least fifty miles, thus allowing an armoured car or gun to keep going long after its tyres have been hit. For his admirable work in connexion with the development of these Run Flat Tyres, Mr. Frank Fellowes of the Sales Department received the M.B.E.

The provision of first rate repair facilities for all types of tyres was obviously a matter of high urgency, and Mr. F. R. Carr, head of the Accessories Division, took an important part in the development of retreading and repair plant.

Wheels

After tyres we come to *Wheels*. Of these Dunlop supplied the following numbers during the war:—

2,500,000 light and heavy disc wheels
600,000 aeroplane wheels
750,000 tank and Bren gun wheels
15,000,000 cycle and motor cycle rims.

I add one or two notes about different varieties of wheel equipment made by the Company:—

Amphibian Tank Wheel

The *Amphibian Tank Wheel* was specially designed for amphibian operations, many of which called for the solution of problems never before met in warfare. The high frequency surface hardening of its rim edges is notable.

Bogie Amphibian Unit

The *Bogie Unit for Amphibian Tanks* uses rim edge hardening and high grade rubber compounding as features of the wheels and tyres. Corrosion from frequent sea immersion is avoided by replacing coil springs with rubber torsion units.

Bren Carrier Wheel

The *Bren Gun Carrier Wheel* changed the design of the original wheel, when casting capacity became difficult, to a fabricated type of wheel which has proved a successful substitute in every respect.

Cromwell Tank Wheel

The *Cromwell Tank Wheel* is a wheel in which a considerable saving of metal is ingeniously effected by moulding the solid rubber tyre directly on to the wheel rim, which in turn is welded on to the periphery of the wheel disc. The result proved successful in every respect, standing the rigorous conditions in which tanks operated in all theatres of war.

Howitzer Wheel

The *17-inch Howitzer Wheel* is the largest pneumatic-tyred wheel of its type at present used in the British Services. It was designed and developed by Dunlop at the request of the War Office.

Horse-Drawn Wheel

In several types of *Horse-drawn Vehicle Wheel*, pneumatic tyres were successfully replaced by a solid metal tread. This is a reversal of the usual history of tyre evolution, and was resorted to because of the necessity to conserve rubber supplies.

Agricultural Wheel

Though *Agricultural Vehicle Wheels* are not service equipment, I feel I must refer to them as they were so vital a feature in Britain's campaign for increased food production. Dunlop produced them for use both on the road and on the land. The principal feature (designed to save the use of rubber in the tyres normally fitted) is a metal tread, giving a wide contact surface to prevent the wheel sinking into soft ground. The solid wheelbarrow and trolley wheel have the same design.

Combine Harvester Wheel

The *Combine-Harvester Wheel* was especially designed and produced by Dunlop. To save vitally needed shipping space during the war, the combine-harvesters imported from the United States and Canada were imported without wheel equipment, an arrangement made possible because Dunlop wheels could be designed to complete the assembly. In these and other developments to help Britain's agricultural industry the expert knowledge of the late Mr. A. J. Airey, Chief of the Agricultural Sales Department, was of great value.

Ball and Roller Bearings

The supply of *Ball and Roller Bearings* was critical during the war, and to ease the roller bearing situation as much as possible special hubs were designed by Dunlop for use with agricultural equipments. The roller bearings formerly used were successfully replaced by a plain bush type of bearing incorporated in the hub, which proved a satisfactory substitute.

Unfortunately I have not space to go into the many interesting points in connexion with the various types of wheels devised for staff cars and war transport vehicles. The development of these was closely associated with that of pneumatic tyres for war vehicles, as, for example, in the 10.00 x 20 divided wheel, which was used on all classes of armoured vehicles to accommodate the run-flat tyre.

Decoys

Some of Dunlop's most ingenious and valuable work was in the production of inflatable dummy guns, vehicles and landing craft used as *Decoys* to mislead the enemy.

Decoys to fool the enemy are probably as old as war itself. In the second World War, however, the decoy guns, tanks and landing craft produced for the Allied armies by the Dunlop organization were markedly improved over any such device hitherto used since the great Greek horse—known, who can say why? as the Trojan Horse—was dragged by the Trojans themselves into Troy.

Decoys were first used on a large scale in the Western Desert in 1941, but these were comparatively crude affairs and were soon replaced by rubber decoys which fooled the enemy in many places and were often successful in turning the tide when the weight of numbers and armament was all against the British and Allied resources. The first decoys were mostly constructed with painted canvas or hessian over wooden frames. They were hard to handle, especially during sand storms, but even so they often deceived the Germans both on the ground and from aircraft reconnaissance.

These early models proved so rewarding from the military point of view that much attention was given in the Middle East to the work of devising better ones. By 1942 great progress had been made in utilizing barrage balloon materials for these elaborate fakes. They had the outstanding advantages of lightness, simplicity of stowage, ease of erection and quick inflation. As development proceeded it was found that considerable improvements could be made by the manufacture of special materials which were not only light but strong, an essential quality in the desert because it was necessary in bad weather for them to be anchored securely. They were brought to such a pitch of perfection that it was extremely difficult to discern at a distance the difference between a real tank or large gun and the decoy. Indeed, as the photographs show, the resemblance of the rubber decoys to the real article was positively startling.

A decoy, which, when inflated, was an almost exact reproduction of a Sherman tank could be packed in a holdall only a little larger than a cricket bag. Its weight was 170 lbs. compared with the 35 tons of its steel counterpart. In the balloon division of the Dunlop Works at Manchester, under the direction of Mr. C. Hemm, it was a common sight to see two women employees pick up one of the "tanks" and cross the room

with it. Five minutes only were needed to set up and inflate one of these elaborate deceptions. On many occasions these decoys were used to delude the Germans, who fired at them and disclosed their own positions, while the real British or Allied tanks were perhaps miles away and were able to profit by the information thus gained.

When the United States entered the North Africa campaign, high ranking American officers became quickly and deeply impressed by the ingenuity and fidelity of these devices. They immediately ordered decoys of their own similar to the Dunlop products except that they had a different pressure inflation system. Up to the end of the war, in Africa, Europe and the Far East, these Dunlop dummies, which for obvious reasons received no publicity during the war, were of incalculable military value.

MISCELLANEOUS

A very few more examples will complete what I have to say about Dunlop's contribution to the war on land:—

Anti-Static Knee Boot

The *Anti-Static Knee Boot* was designed for use in the shell-filling rooms of explosive factories, where there is a danger of explosion due to sparks from unearthed static electricity. Between 1938 and 1945 Dunlop produced more than 6,000,000 pairs of these and other rubber boots for use in the Services and by war workers, and nearly three-quarters of a million pairs of rubber boots have been repaired for the Services, including the United States Army. Dunlop also initiated a process to assist boot repairers to undertake this work, and a further half million pairs were repaired by them.

Stirrup Pump Hose

The *Stirrup Pump Hose* became familiar to almost every man, woman or child in Britain through A.R.P. equipment. Dunlop made 45,000,000 feet of it—more than the diameter of the earth.

Tank Suits

The *Tank Suit* was an overall suit, which could also be used as a sleeping bag, made to provide protection for tank crews in all weathers. In the last winter of the war, after the invasion, it was an inestimable blessing for the crews who drove forward in tanks through blizzards and extreme cold. It was made from 170 different parts and has twelve pockets. This is only one of seventy different types of clothing made for the Forces in Dunlop factories.

Printers' Rubber "Blankets"

Millions of maps were printed on *Printers' Rubber "Blankets"* manufactured at Cambridge Street for use on D-Day.

As final chance items of Dunlop's infinite variety of defence contribution I would mention:—

3,000 miles of rubber tubing for various purposes from detonators to blood transfusion.
600,000 pairs of anti-gas gloves and
1,000,000 gun-muzzle covers.

CHAPTER XII

DUNLOP'S WAR EFFORT

(*iii*) THE SEA

COMING now to Dunlop's contribution to the equipment of the Senior Service, I must give first place to the famous under-water swimming suit, which helped so greatly in clearing the Normandy beaches. Truly one can say of these, with Horace:

Merses profundo, pulchrior evenit,

which Sir Edward Marsh translates:

Wouldst drown them deep? More glorious they arise.

The Cabinet was well aware that, soon after the Germans occupied Northern France, they had begun preparations to repel an Allied invasion by sea which they knew would in all probability be attempted over a comparatively narrow stretch of the Channel coast. Their engineers, using the utmost ingenuity backed by lavish supplies of steel, set about erecting underwater obstacles in the shallow waters round the Normandy beaches. These were designed to tear the bottom out of any approaching landing craft and were heavily mined with every sort of infernal explosive which German ingenuity could devise. Their existence was first spotted by low-flying aviators to whom they were clearly visible at low tide. Reconnaissance planes were sent to take extensive photographs almost at water level; a highly hazardous feat. From these photographs Allied engineers were able to make full-scale models and to study the means by which they might be destroyed.

The German obstacles were of various types, but the most formidable was known in official reports as Element C. This was a mass of steel constructed like a huge picket fence of six-inch angle iron, having a frontal area of 10 feet by 10 feet, heavily strutted rearwards from a base measuring 10 feet by 14 feet; the whole unit weighing 2½ tons. Each unit was heavily mined with land mines of the "Teller" type, or with specially prepared artillery projectiles.

Having learned how the obstacles were constructed, the problem of the Allied engineers was to devise some method of destroying them without leaving masses of twisted steel girders, which would have proved as great a difficulty for landing craft as the original obstacles. They had therefore to be so destroyed that the resulting debris would not rise more than 18 inches from the bed of the sea.

Long and patient experiments were carried out. It was found that a total of 36 explosive charges was necessary for the required destruction, which must of course be wreaked over a wide stretch of beach, in order to enable considerable landing forces of men and materials to get through to the shore.

Four points stood out for the military and naval authorities who had to plan the invasion. When the time came, the work would have to be done quickly and completely. It was a task that called for supermen. These men would have to work under an unknown depth of water and so must virtually become human fish. How were they to be clothed and equipped for this supremely dangerous venture?

Here Dunlop enters the picture. But first a word as to the men who underwent the long and strenuous training necessary for this vital and perilous work. They were all volunteers and all in splendid physical fitness. They were officially (and most dully) called the Landing Craft Obstruction Clearance Units, but the popular name of "Frogmen," given to them after their fame had become known is, as so often, less clumsy, more descriptive and presumably permanent. The Frogmen's task was to slip unobserved from small rubber dinghies at dawn on D-Day, and to make all speed in blowing up the obstacles confronting the heavily loaded landing craft.

As it turned out, the work was even more hazardous than had been expected. D-Day had already been postponed twenty-four hours because of adverse weather conditions, and when the Frogmen reached the scene of their exploit high winds and rough seas had combined to produce a low tide some eight feet higher than usual off the beaches at that time of year. This forced a shortening of the time allowed for blowing up the obstructions, and in the event the men were not able to get back to the parent craft waiting for them offshore, but had to carry on in the face of intense enemy mortar, shell and machine-gun fire directed at them while they worked. The success of the invasion is the measure of the skill, coolness and tenacity with which they did their work.

Dunlop's important part in this famous underwater exploit was the clothing and equipment of the men. Frogmen were clothed in close-fitting watertight suits designed by Dunlop in collaboration with the Admiralty's Superintendent of Diving, and produced exclusively at the Cambridge Street works; their development and production being entrusted to Mr. W. G. Gorham, whose connection with the Franks Anti-G. suit has already been mentioned. These suits were sea-green in colour for reasons of camouflage and had tight-fitting rubber hoods, which gave wearers the appearance of gnomes. They were equipped with swimming fins on their feet to give speed and mobility in water, and with Admiralty breathing apparatus for use when submerged.

The swimming suits had their origin early in 1942, when certain problems arose over the Admiralty's development of the prototype Midget Submarine, which necessitated a close-fitting diving outfit much

less cumbersome than anything then invented. Dunlop was asked to help in this problem and after months of careful experiment found that a rubberized stretchable stockinette gave the best results.

By the end of 1942 the formation of units to serve as Underwater Swimming Saboteurs was in urgent demand. The main difficulty was to evolve an extremely supple, close-fitting suit which would not impede the diver's movements but would yet give him ample protection against the chill of cold water. The diver was also required to be able to paddle a canoe, and further, to operate ashore without discarding the suit. These requirements necessitated a complete departure from everything learned in the manufacture of old-style diving suits, which were ponderous as well as voluminous; and they furthermore assumed that the diver would be walking on his feet or moving about on all-fours as well as diving and swimming.

The use of an all-rubber dress was excluded, partly by the ease with which it might be damaged and partly by the need for economy in natural rubber. Rubberized stretchable stockinette was adopted because it had important advantages for ease in dressing, handiness in tight places, and lightness.

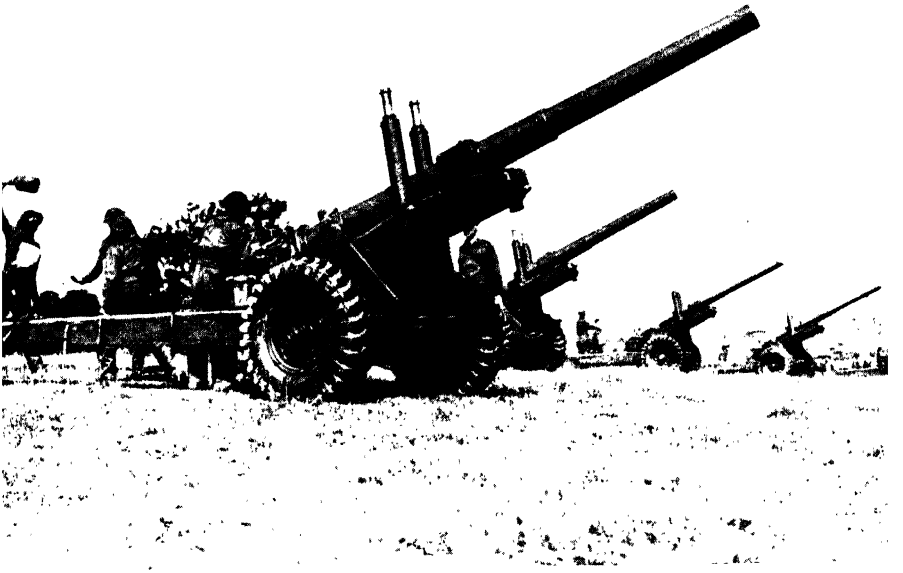
At this stage modifications in the shapes of the trousers and jackets of the earlier suits were determined by careful trial, since generous dimensions were precluded by the necessity for good streamlining. It was now that points essential for ensuring complete freedom of movement were accurately established: mainly for raising arms above heads and bending bodies and knees.

With the work of determining the basic features for a close-fitting dress went the means of getting into it, the making of a watertight seal at the point of entry, the venting of the dress to exclude all air when in the water, the provision of fins for the feet, the design of a streamlined hood and of a face mask to give the best possible range of vision for the diver. All of these, in combination, had to provide the diver a reasonable degree of comfort when dressed and ready for long immersions, and to allow him to dress and undress himself unaided if necessary.

To ensure good stream-lining the means of entry was provided by incorporating a shoulder yoke of rubber, whose high stretch and excellent resistance to tear would make it practicable to stretch a hole 4½ inches in diameter cut in the yoke at the neck line wide enough for the passage of the body and arms. This yoke was manufactured from the special rubber sheet used to make petrol tanks self-sealing.[1]

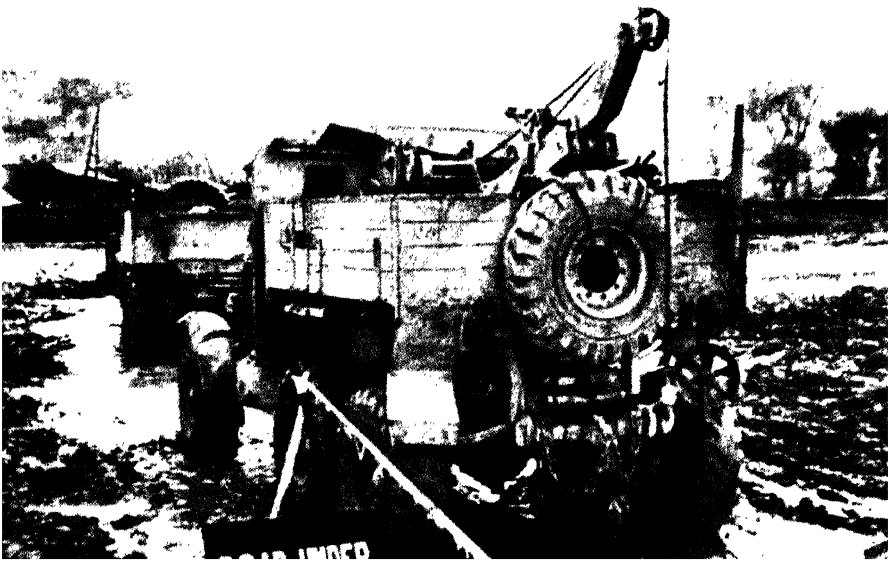
By this time many experiments in the use of the suit were being made in close association with a special unit of the Royal Marines calling itself Boom Patrol Defence, which was training in great secrecy with the suits for purposes by no means disclosed in their title. This unit helped to solve many problems, notably proper venting to prevent air

[1] *See* pages 34 and 57.



TYRES FOR THE TROOPS:
(See Chapter XI.)
Above: 2. For heavy guns.
Below: 3. For Paratroops' motor-cycles.

TYRES FOR THE TROOPS:
(See Chapter XI.)
Above: 4. For armoured cars.
Below: 5. In mud.



being trapped by the suit and producing positive buoyancy, which would have to be counteracted by otherwise unnecessary weight.

The use of fins attached to the feet as an aid to swimming is not a new device. They have been used for many years for sporting purposes in warm waters. Nevertheless, suitable patterns had to be developed for the Underwater Swimming Suits. It was then discovered that no samples of fins could be found in Great Britain, and, after that, the first consignment from abroad was lost by enemy action in the Atlantic. By this time the supply of fins had become an urgent Service need and therefore the Dunlop Organization started to make its own models. By the time a second consignment had arrived many Dunlop fins were already in use. Comparative tests showed that these, although hurriedly designed and produced, gave just as good results as those imported.

It was now considered advantageous to provide an undersuit to streamline the wearer and ease dressing, as bunched up clothing tended to impede entry into the suit through the 4¼ inch diameter hole in the yoke. The undersuit was produced from stockinette material with *Lastex*[1] panels inserted in those areas where freedom of movement is required. Sponge rubber shoulder pads were also incorporated in the suit to prevent any possibility of discomfort from pressure on the collar bones caused by the metal neck ring. The undersuit also served the purpose of a uniform for attaching Service recognition badges and insignia where operations made these necessary, as for instance, when there was a risk of capture by the enemy.

The design of the face mask used deserves special remark, for it has proved to be an important achievement. A number of hoods completely enclosing the face had been produced before a quickly detachable face mask was considered, of which the visor and breathing-set mouthpiece and "cock" formed an integral part. With the former system it was necessary to break the neck seal and remove the hood to uncover the head for comfort, while sitting at the "ready." In consequence it took a little time to prepare for the scramble into the water.

Tests were therefore made with the object of using a separate face-mask to fit in close contact with a hood having a cut-away face opening. To secure a pressure-tight joint round the edge of face masks generally, even with a range of sizes to fit varying shaped faces, had long been a difficulty; therefore it was with some diffidence that the problem was tackled. Eventually a perfect seal was produced, of one size only for all face dimensions. These good results were enhanced by a pressure joint without any special mechanical securing device for the 4¼ inch diameter Perspex window. This has a moulded rubber groove which enables the window to be taken out or replaced with ease while the mask is being worn.

During the dress experiments the limitations of the existing Admiralty

[1] See Glossary.

underwater breathing apparatus became apparent, for no apparatus had been designed for comfortable breathing in every position which a swimming diver may assume, and the underwater swimming suit had made every conceivable swimming position practicable. Moreover the physical energy expended by a swimming diver is greater than that of the old-style diver. It therefore became essential to find ways to reduce to the very minimum the effort of breathing under water in all positions, and at the same time to ensure good streamlining.

Much time was given to the design of a suitable apparatus, and after many trials an experimental set was constructed where reduced resistance to breathing was made possible by the placing of a specially designed breathing bag assembly, so that the diver always had the inflated position most comfortable for breathing. After many trials by the Admiralty Experimental Diving Unit and the Royal Marine Boom Patrol Defence Unit, and exhaustive tests made by medical experts of the Admiralty's Personnel Research Committee at the National Institute of Medical Research and elsewhere, this breathing apparatus was accepted for Service use and registered as an Admiralty patent number.

In August 1944, a further dress was specially developed for use in X-craft, or Midget Submarines. It eliminated certain disadvantages in the suits formerly used and has greatly contributed to the success of many British underwater exploits. These X-craft had to be able to force a passage unobserved through anti-submarine nets in closely defended harbours. A special airlock was built into the craft, from which highly trained divers emerged on to the upper deck. Armed with net cutters, they severed the heavy wire strands of the nets, allowing the submarine to nose her way through the gap they made. In the cramped quarters of X-craft, dressing a diver was extremely difficult, but a slight modification of the equipment enabled this to be done with remarkable ease. Furthermore, the improved streamlining of the dress effectively prevented the diver fouling in the narrow hatchways. By intensive training the time for the whole cutting operation was reduced to a matter of minutes, and no disturbance of the surface part of the nets was visible to even the sharpest look-out ashore. The same technique was used for placing delayed action "Limpets" on ships' bottoms.

X-craft divers wore either fins or special streamline boots (produced at Dunlop's works in Brook Street, Manchester). On one occasion a diver wearing fins was swept from the submarine as it surged through the nets but, thanks to his underwater swimming gear, he was able to overtake it and regain the hatch.

All X-craft operating in the Far Eastern War Theatre were equipped with this Dunlop underwear suit.

Few chapters of the war have caught the imagination of the British people, and indeed of the whole world, more vividly than these exploits

of the "Frogmen." It has been universally recognized that here was something new in war, something new in heroism and a British contribution towards victory of outstanding merit. The equipment used by these brave men, and their methods of operation, have been shown in displays all over the country, which hundreds of thousands of people have visited. The Dunlop Organization is proud to have been the designer and exclusive producer of this equipment, which appreciably reduced the cost of the war in human life.

The invasion of Normandy was not the only landing operation in which the frog suits were used. For example many awards were made to frogmen for deeds of outstanding bravery in connection with the later landings at Walcheren, and some outstanding exploits were carried through by men in swimming suits operating from midget submarines. One of the most striking of these took place in the Straits of Johore, where it was known that the Japanese cruiser *Takao*, of 9,850 tons, was guarding the entrance to Singapore. *Takao* and another cruiser, *Myaoka*, were being used as floating forts, and British midget submarines were given the task of sinking them.

On 31st July, 1945, the midget *XE*3 set off on this errand, making a six-day journey from the parent ship, H.M.S. *Bonaventure*, before *Takao* was sighted. *XE*3 had to make a very slow approach through heavily mined waters. When only 250 yards from the cruiser, the commander of the submarine, Lieut. Ian Edward Fraser, V.C., decided to have a last look through the periscope. This proved a perilous undertaking, for it revealed a Japanese motor boat only 20 yards away—and the periscope had to be hurriedly submerged.

Takao was in shallow water, and an attempt to take *XE*3 under the forehead only resulted in its bumping along the bottom and into the cruiser's side. The submarine had therefore to manoeuvre round for more than three-quarters of an hour before finding a hollow in the sea-bed about amidship of the cruiser; this hollow she was forced to enter to make her attack.

In order to fasten his bomb to the cruiser's side, the diver, Leading Seaman James Joseph Magennis, V.C., had to squeeze himself out of a half-opened hatch, which had jammed against the side of the cruiser, before he could get to work. *Takao*'s hull was covered with barnacles and seaweed and it took Magennis 45 minutes to scrape these off and to attach his limpet mines. All this time a stream of bubbles was unavoidably being sent to the surface, and there was deadly danger that these tell-tale bubbles would be seen from the cruiser's deck.

Having finished this part of his work, and the equally perilous task of getting back into the submarine, Magennis, with his commander, was confronted by the hazardous necessity of escaping without being seen. But when Magennis did get back to the submarine he found that the mine carrier, which is jettisoned after it has served its purpose, would not disengage. As its mass would seriously alter the trim of the submarine,

he had to risk leaving her for the second time to release this apparatus with the aid of a spanner and hammer, all of which added to the vibrations already set up, and thereby increased the danger.

After Magennis had returned the second time, *XE*3 moved off in safety, but half a mile away accidentally surfaced. Fortunately she was not spotted by the enemy, who remained unaware of the death ticking ever nearer on the side of their own vessel. Six hours after *XE*3 started on her five-day return to the *Bonaventure*, there was a terrific explosion as the limpet mines blew up. Later on it became known that the operation had proved a complete success and that *Takao's* bottom was blown wide open. For their gallantry in this marvellous operation both Lieut. Fraser and Leading Seaman Magennis were awarded the Victoria Cross.

On the same day as the above operation, another midget, *XE*1, also from *Bonaventure*, completed her assigned task. This was to cut the cables running from Saigon to Japan and from Saigon to Singapore, an action which, if successful, would seriously impede Japanese communications in a vital area of operations; leaving them only wireless telegraphy which, unlike submarine cables, could be tapped and decoded or decyphered by the Allies.

*XE*1 was commanded by Lieut. M. S. Sheen, D.S.O., R.A.N.V.R., and the divers were Sub.-Lieut. K. M. Briggs, R.A.N.V.R., and Sub.-Lieut. A. K. Bergius, R.N. These two, as Magennis had, all wore the Dunlop underwater swimming suit.

Lieut. Sheen took his craft into the entrance of Saigon harbour at night. Submerging at daylight after a five-day journey from the mother ship, he began trawling operations for the Singapore cable. The first two runs over the sea-bed swept with a grapnel failed to find the cable, but on the third run it was picked up in forty-two feet of water.

Sub.-Lieut. Briggs left the submarine and was at once trapped in slime up to his armpits. He managed, however, to free himself and to cut the cable. As the cable broke he was swept along by a two-knot current. He anchored himself to the cable by the cutter, and finally returned to the submarine with a one-foot length of the cable as evidence of success.

Later the same day the Japanese-Hong Kong cable was found, and Sub.-Lieut. Bergius left *XE*1, cutter in hand. He had trouble with this cutter and had to return to the craft for another, with which he succeeded in cutting out a section of this important cable.

Many people have wondered whether the Germans had any equipment for underwater operations to compare in any way with the Dunlop swimming suit which made possible the great invasion. The answer is that they had not. With all their genius for destruction, they failed to design anything comparable in efficiency to this equipment used by Britain and the Allies.

British superiority over Germany in diving equipment may be seen from statistics recently divulged. The total output of diving dresses in

all Germany from 1889 to the end of this war—over half a century—is now known to have been about 3,500, whereas Dunlop has manufactured more than 3,400 in the two years since January 1944. In addition, they have supplied the Admiralty with many other components for shallow water diving dresses, for which 4,600 special rubber helmets and appropriate watertight cuffs were made.

The German production as to 85 per cent has been the old-style diving dress with metal helmet and air line supply. We have learned since the end of the war that the Drager works at Lubeck, the largest producers of diving gear in Germany, had connections with a certain Dr. Hess, who had used a gas mask breathing apparatus and swim fins for naked swimming in the Caribbean Sea. But Drager seems not to have pursued this line of experiment to the point of large-scale manufacture, nor indeed are there records of any experiments whatever.

One of the more spectacular German exploits of the war, which many will remember, was the attempt of certain German Olympic swimmers to blow up the important bridge at Nijmegen after they had floated down the Rhine for many miles. This attack failed, but it achieved much publicity for the swimmers. At the time experts believed that the equipment used by these swimmers was of Italian origin, and it now seems probable that they were in fact trained at an Italian base.

The deep appreciation felt by the Lords of the Admiralty for the Dunlop swimming suit and the achievements it enabled at the crisis of the war is conveyed in the following letter, which the Company received under date of 9th February, 1946:

The Secretary of the Admiralty,
Admiralty,
*London, S.W.*1.

Reference T.O. 6783-45.

Sir,

(1) *I am commanded by My Lords Commissioners of the Admiralty to acquaint you that Their attention has been drawn to your most valuable work and co-operation in the development and manufacture of diving equipment since your Company was first approached by the Admiralty Diving Committee early in* 1943.

(2) *My Lords have noted particularly that the successful development of four different types of Underwater Swim Suits, the Underwater Swimming Breathing Apparatus and some thirty different accessories, has been mainly due to your ability and initiative, and the high degree of effort put into the design and trials of such equipment.*

(3) *Credit is also due in connection with the repair service for Dunlop Equipment and the Maintenance Courses, as well as the prompt attention and carrying out of experimental work on the Franks Flying Suit.*

(4) *I am accordingly to forward to you an expression of Their Lordships' appreciation and thanks for the services you have rendered in the development and*

prompt production of these vital equipments, the workmanship of which proved to be of a very high standard.

I am, Sir,
Your obedient Servant,
(*Signed*) RICHMOND WALTON.

W. G. Gorham, Esq.,
Dunlop Rubber Co., Ltd.,
Cambridge Street,
Manchester.

Another device produced by Dunlop for landing operations was the *Pneumatic Wave Controller*, the largest device ever produced anywhere in the world by the Rubber Industry.

When the invasion was being planned, one of the factors which no amount of military care or foresight could foretell for certain was the size of the waves which the landing craft would encounter as they made the dash for the beaches. In collaboration with the Admiralty, the Dunlop Organization made what became known as the Admiralty Pneumatic Wave Controller. These wave controllers were made in units 200 feet long and 25 feet high. They were clamped with 500 bolts to a 700 ton keel made of concrete, and were anchored to the sea bed at the ends. It was calculated that a number of these units, set in line, would reduce a 6-feet wave to approximately 1 foot. Each completed unit had a total weight of 711 tons.

The deck of these pneumatic pontoons was made of multiple heavily rubberized cotton material divided into four chambers with a capacity of 7,000 cubic feet each. Each of these four chambers had to be able to maintain its individual pressure for at least 7 days. The outer chamber had a pressure of 1-lb., the second 2-lbs., the third 3-lbs., and the fourth 4-lbs.

When a number of these units are set in line broadside to the waves, the waves strike the outer chamber, which may absorb the blow with consequent almost quiet water on the landward side of the unit. If, however, the wave is very heavy, the pressure is transmitted to the second, third or fourth chambers which, with the pendulum action of the 700 tons' concrete keel, will reduce a 6-feet wave to about 1 foot.

Closely allied to the wave controller from the engineering and manufacturing point of view were the "*Beetles.*" These were heavy and powerful pneumatic units which could be inserted in damaged compartments of the concrete pontoons supporting the floating bridge attached to the Mulberry Harbour. The speed with which these powerful units could be inserted and pumped up contributed materially to one of the greatest exploits in the history of war.

A material, developed by a subsidiary of the Dunlop Rubber Co., which proved of great value for the decking of ships is known by the trade name *Semtex*. This offers advantages which no other form of decking

material can claim. Battleships, aircraft-carriers, cruisers, destroyers, corvettes and minesweepers are among the different classes of ship whose decks have been treated with various types of Semtex compounds.

There are three types:

(*a*) A plasticized grade, oil resistant, non-inflammable, non-smoke-producing and completely non-skid, laid direct to the clean steel exposed decks and gun carriages of fighting ships;
(*b*) A reclaimed rubber plastic grade, used as an underlay, laid direct to steel decks upon which Admiralty plain or decorative linoleum is super-imposed;
(*c*) A Semtex plastic composition laid and bonded to steel decks in washplaces and lavatories, giving water resistance, safety and comfort underfoot.

Each type is flexible, bonds positively to steel, is anti-corrosive, resistant to oil and sea water and remains entirely non-skid whether wet or dry.

From the beginning of hostilities to the end of 1944 more than 1,500,000 square yards of Semtex decking treatment have been carried out in fighting ships in this country and in Admiralty dockyards overseas.

More than 30,000 linear feet of Semtex streamlining treatment to secret underwater devices, on ships' hulls, etc., has been undertaken.

Apart from work afloat, work in Degaussing (anti-magnetic mine) and cable protection, to the extent of 150,000 linear feet, both inboard and outboard was done by Semtex Ltd. About 250,000 square yards of Semtex special fleximer floorings were laid in emergency hospitals, hutted camps, agricultural hostels, etc., in order to overcome difficulties experienced with ordinary materials.

The jointing of main stoneware pipes carrying chemical effluents from Royal Ordnance factories, and the protection of brickwork against acids, were also carried out with specially devised Semtex materials.

These services essential to the war effort were maintained in face of the utter failure of rubber latex supplies, on which the whole technique of Semtex had previously been based, and their maintenance constitutes a remarkable achievement of the Semtex organization, the leader of which is Mr. F. G. Mottershaw, Managing Director of Semtex Ltd.

Dunlop produced many other articles of less importance for the war at sea, such as the rubber "*X*" *Boat* (weighing only 64 lbs.) for secret landing operations on enemy coasts in conjunction with submarines, and so constructed that if one half is damaged the other half remains inflated, and retains its buoyancy: *Magnetic Mine Appliances*, including rubber sleeves and floats designed for use in mine-sweeping operations, and a *buoyant hose*, which floats on the surface and is used for refuelling ships at sea. These, however, lack of space prevents my describing more fully.

So ends my necessarily brief catalogue of Dunlop's contributions

to the war effort. It is unfortunately impossible to estimate the Company's share in the thousand million pounds' worth of goods and services supplied by Britain to the Allies during the war as the Ministry of Supply contracts do not disclose the destiny of the goods. But it is known that the Company provided:

For U.S.A.

Giant, car, cycle and solid tyres.
Aircraft tyres and tubes.
Semtex flooring for aerodromes and other installations.
Barrage balloons.
Stabilizer fins and snatch clips.
Aircraft lifting bags.
Components of prefabricated harbours, floating breakwaters and camouflage.
Field jackets.
Mackinaw coats.
Trousers.
Officers' field coats.

For Russia

Giant tyres.
Conveyor belting.
Proofed cloth.
Hot-water bottles.
Rubber boots.
Tyre retreading plant.

According to Brig.-Gen. Morris Berman, U.S.A. Air Service Command, more than 64,000 tyres and 41,000 tubes of various types and sizes were supplied by Britain to U.S.A.A.F. by the end of 1944.

CHAPTER XIII

DUNLOP CLOTHING AND THE WAR

To conclude this section on Dunlop's contribution to the war effort at home, I shall add two sketches showing how the war affected their two London factories which were compelled to turn over practically the whole of their energies to new products, and which served all the three Fighting Services in the course of their activities. These were the Clothing Factory at Edmonton and the Sports Goods Factory at Waltham Abbey.

EDMONTON

Dunlop is so important in the Rubber world that people otherwise well informed are apt to associate the name almost exclusively with rubber. The truth is that for many years the Company has also held a leading place in the clothes manufacturing industry. In the years before the late war it made a great variety of articles of clothing, most of which had some form of rubber or chemical waterproofing as an important feature.

It is evidence of the importance of the Company's work in this field that Mr. W. Lemkin, C.B.E., the General Manager of the Clothing Division, was appointed in 1940 director of cotton textile production at the Ministry of Supply and later director of Clothing and Textiles.

Dunlop methods of clothing manufacture include mass production and the conveyor system, which are more widely known to the public in the motor car and other engineering industries. When war came, it was these already successful methods of operation that made possible the immediate swing-over from sports jackets to battle dress. At once, Service demands began to mount, beginning with Army greatcoats and Admiralty raincoats. Service requirements are very rigid and have to be carefully observed, but this presented no difficulty to Dunlop, whose clothing standards in peace-time had been of the highest, so that their trained operatives had little trouble with their new tasks. So rapid was the increase in production that even in 1940, when the war had hardly got into its stride, Dunlop produced 50,000 battle blouses, 70,000 pairs of battle trousers, 60,000 greatcoats, a vastly increased number of ground sheets and many other items in smaller quantities.

Although every division of the organization had its own troubles—great and small—the clothing factory at Edmonton always seemed to have more than its fair share. For one thing, the factory appeared to be a junction on all the principal lines of every sort of air invasion, whether by pilot-borne aircraft, flying bombs or rockets. As related elsewhere, Dunlop was a pioneer in roof-spotting and this was a great help in maintaining production in the clothing factory. There were, for instance, on

2nd-3rd October, 1940, nine air raid warnings at the factory. Although these covered a productive period of seven hours, less than two hours' production was lost.

A main problem at Edmonton was the constant loss of trained staff, and to explain the reasons why this was especially troublesome in the manufacture of clothing some description of the conveyor system is necessary. The principle of the conveyor is that it brings to each machine operator, by means of a slowly moving belt, just that amount of work which a trained machinist can be expected to do on a particular segment of garment before the belt passes to the next operator. The number of operators on one conveyor varies according to the nature of the garment, but is generally between thirty and forty. With a reasonably stable labour force, each operator will acquire a high degree of skill in relation to which her work and the time allotted to it (and that of her equally skilled colleagues) are carefully planned and calculated. This is team work developed as highly as the operations of a first-class football eleven. But, as in the football team, if one skilled performer drops out, the factory manager may have to rearrange and regroup his whole team, with immediate loss of speed and production.

Such, then, was the situation at Edmonton when war demands for clothing started to expand in 1940. The system was admirable, and increasing demands were admirably met. Then began labour shortages, as skilled operatives volunteered or were called up for the Forces. Compelling publicity through the Press and radio made the nation's deficiencies in tanks, guns and planes apparent to all, and everyone was eager to do something to make up Britain's lack of these major instruments of war. Next came the direct appeal to women to enter the heavy industries, and women rightly felt that by taking men's places they were making a very important contribution to the war effort.

But the clothing trade had not much glamour or direct appeal, and losses of workers became increasingly difficult to make good, particularly as the protection of the Essential Works Order was not extended to the clothing trade until June 1942, by which time a high proportion of key operators had joined the Forces or had been directed to other work.

The entry of Japan into the war, with the consequent loss of natural rubber supplies, complicated things still more for the waterproofing section of the clothing division. Synthetic proofings were tested, but none met all the requirements or reached the standard of a rubber-proofed garment.

Nevertheless, in spite of all the troubles that developed out of labour shortage and from enemy attacks, production neither ceased nor slacked. Juvenile labour was found to be remarkably adaptable and worked splendidly.

Meanwhile demands grew. The Americans came into the war and Dunlop provided many thousands of garments for the United States Army. These included some which had never been made in Britain

before but which soon became a common sight in British streets. Some of them were lined field jackets, "enlisted men's"—Other Ranks'—jackets and trousers; Mackinaw coats, the three-quarter length coat which attracted so much notice, and trench coats. These were made both for enlisted men and for officers. The officers' trench coat was a first-class piece of tailoring as of materials, with a detachable fleece lining which could also be used as a dressing gown—altogether a highly enviable garment. Because of its many "gadgets," each coat boasted no fewer than 64 buttons all sewn on by hand!

The flying bomb affected the clothing factory in two ways, one constructively and the other destructively. When the missiles began coming over, two conveyor units were switched to making additional parts needed in barrage balloon construction, so that while the enemy were trying to wipe out the factory, that same factory's balloons along the south coast were materially reducing the number of bombs that reached London.

The approach of D-Day brought still further demands on the factory, and at very short notice the waterproofing department began manufacturing such variegated articles as hatch covers for Humber Scout cars, mine detector bags and dynamo covers.

The war in the Far East put the screw yet more firmly on to the clothing factory. Very severe hardships and difficulties had been imposed on the British and Allied Forces by jungle rot. Food, surgical dressings and other items which a soldier must carry with him must be protected from this misery. The Dunlop share in assisting the Army over these difficulties was in the production of food bags and pack bags. These were made from special waterproof material with the textile part also proofed against jungle rot. Hard as were the conditions under which all ranks had to serve in that abominable theatre of war, things would have been harder still but for the alleviation provided by this protection.

For five and a half years of constant enemy attack, the Clothing Division continued unscathed. But it suffered an appalling piece of bad luck less than a month before all enemy attacks ceased for good. At 2.35 a.m., on Saturday, 3rd March, 1945, a rocket bomb scored a direct hit in the centre of the larger of the two factories at Edmonton. There could not have been a squarer hit nor in a worse place. The fire caused by the explosion quickly spread among the inflammable materials which were in every part of the building and within a few minutes the whole place was ablaze. The waterproof factory together with the warehouse and the despatch department were completely gutted.

Considering the almost complete destruction, and the masses of twisted girders and crumbled walls, it seemed impossible for any human being to have emerged alive. Nevertheless, by what seemed a miracle, not one of the night watchmen on duty was seriously injured.

Within half an hour of the explosion, Mr. J. D. Donaldson, the Works Secretary, and Mr. J. Gooderham, the Works Engineer, were on the spot,

together with members of the maintenance staff. Without losing a minute they set to work as close to the flames as they could get to save whatever could be saved.

Gradually order was restored. Managers, staff, handworkers, cutters, machinists and packers all gave a hand in restoring working facilities and in protecting what had been saved. Temporary walls of asbestos sheeting were erected to keep out the worst of the weather, benches were installed, and gradually the outlines of a working plant began to take shape. On 27th March—barely three weeks after the catastrophe—work began on waterproof garments for the Ministry of War Transport.

The rainproof factory, separated by about fifty yards from the demolished building, escaped from burning but was heavily blasted. It was at once apparent, in the glare from the blazing buildings, that a colossal mass of work would have to be done to get production going again. Jagged splinters of glass from roof and walls had been showered over cloth, coats, cutters' tables, machines, presses and conveyors: over shelves, floors—over everything. Before daylight, clearing had been started and by Monday morning the rainproof factory was again in production.

Thus the Clothing Division had its own grim experience in Dunlop at war. Its members faced every difficulty with confidence and when the supreme test of survival came, so heartbreakingly near the end of the war in the air, they met and endured it with the discipline and courage of trained soldiers.

CHAPTER XIV

DUNLOP (WALTHAM ABBEY) AT WAR

WALTHAM ABBEY

WHEN war broke out the Dunlop Sports Division with its Racket Factory at Waltham Abbey seemed to be about as far removed from anything useful to the war effort as could well be imagined. It passed, during the period of the "phoney war," a comparatively uneventful life producing rackets and other games implements, as requested by the Government, for the export market. The only reminders of hostilities were the disappearance of familiar friendly faces and the many export orders which had to be made up three or four times over to replace goods lost at sea.

But Dunkirk shook Waltham as it did all Britain. With great pride and zeal the Sports Division (of which Mr. A. E. Burden is Manager, with Mr. Guy Proctor, as Manager of the Racket Factory) undertook its first war work, which grew in volume quickly, until all departments had been invaded. The sports side by then was living on its fat—the enormous peace-time stocks—of which a very skinny remainder survived as late as 1945. New names, new methods, new materials—new everything, interested all, as one after another balloon fins, gas valves, snatch clips, ballast release fuses, clog soles, valve hoods, turret hoods, life belts, invaded the factory repertoire.

One of the first products to be made were the above-mentioned fins for barrage balloons. These formed the fin section of the mobile balloon used by ships in convoy and they had to be produced very speedily because of the heavy shipping losses which began shortly after Dunkirk. These balloons flew at the end of a thin steel cable which was run out from a winch on the ship's deck. Three fins were fitted to each balloon, and were necessary as stabilizers.

Well can workers remember, in the critical 1940 days, R.A.F. lorries waiting day after day at the factory doors to collect last minute balloon fins to be rushed to the docks for the protection of Middle East convoys. In those early days Dunlop staff were not so conversant as they became later with the innumerable Government forms and red tape, which seem inseparable from official business, and there were many arguments to be straightened out. Meanwhile the lorry, the driver, the evidence, and everyone concerned, except the Dunlop workers, would have vanished into thin air along with the convoys.

Some articles made were so shrouded in mystery that one factory humorist was able to persuade his fellow workers making "Snatch

Clips" (a peg-like safety device for balloons) that they were producing Army issue clothes pegs for ranks above that of Captain.

Officialdom was considered to have run riot when men were asked to make "Ballast Release Fuses". But when it became known that Fort Dunlop were making mysterious balloons and that, according to neutral Press reports, leaflets were being found all over Europe, release fuses and their "ballast" suddenly became actualities. They were in fact the most vital part of the small balloon already described which could bombard enemy territories with propaganda leaflets whenever wind and weather were suitable.

Presently word went round that there was a shoe leather shortage, and that hundreds of wooden clog soles were required. "Can we make them?" "But how?" "Oh! use your heads." "We" did and made thousands. (As, when a wooden chancel floor was required for St. Paul's Cathedral, Canon Sydney Smith suggested that the Dean and Chapter should put their heads together).

By 1941 machines were running day and night, seven days each week. Everyone was being pressed to the limit of endurance; individuals were getting tired and irritable. There must be more help. Salesmen came to act as inspectors and planners, housewives came, some for the mornings, some for the afternoons; special cars collected girls from the outlying villages and somehow the workers "managed."

Voluntary fire-watch began long before the official schemes started and became in many ways a social break in which lasting friendships were made.

There were countless air raid alarms, particularly in September 1940, when everyone raced to the shelters time and time again, until, heartily sick of it all, management and men got together and hammered out a spotting scheme which allowed production to continue almost normally. The same thing happened when V1's roared over later. The second V1 to cross the London area blazed its way right over the factory one night—with fireguards watching in blissful ignorance of its true nature.

Throughout the war the factory, shaken severely by many near misses, received no damage whatsoever, until one of the last V2's fell within a hundred or so yards. Glass flew everywhere, roofs were lifted and some of the structure sagged but, miraculously, there was only one slight casualty.

So, despite air raids, material and labour shortages, new and strange tasks, transport and fuel difficulties, no worker—man or woman—lost heart, gave up, or slackened, and the work went on.

The Dunlop Dartboard

From the game and play of Darts to the death and destruction of war should be a far call; but the dartboard has since 1939 proved such an added amenity—I had almost said necessity—for the Mess by land

and by sea (as well as for public houses—and private houses) that I consider myself entitled to add this achievement as a footnote to the war contribution of the Tennis Racket Factory, particularly as Waltham's war-time experience has revolutionized the manufacture of the Dunlop Board.

When shown a Dunlop dartboard one would incline to guess that it is made of rubber or cork, or perhaps rubber and wood. In fact, the board before the war used to be made out of rushes imported from China and Japan. Very soon after the war broke out, the supply of rushes began to fail and it became urgently necessary to find a substitute. After considerable experiment it was discovered that a much superior material could be made from wheat and other straw compressed by a process developed at this factory into a density greater than that of aircraft spruce, and able to be cut and glued like wood. Indeed, the Company had once the rich satisfaction of receiving a sharp official query as to how, without licence, they had obtained the timber for the manufacture of dartboards.

The straw is brought to the factory from neighbouring farms, cleaned of weeds, arranged by lengths in bundles, which are hydraulically pressed to one-fifteenth of their original loose volume: it takes 10,000 feet, or some 60,000 two-inch lengths running from one surface to another to make one dartboard.

The pressed blocks are cut, fashioned and reassembled, and the pressure now needed to drive the four circumference strips of mild steel, three-quarters of an inch wide, is about sixteen tons. The dart point can pass between the adjacent surfaces of the straw without damaging the straw itself, and the system works so well that Waltham frequently hears of boards which have survived one and even two years' hard public service. In this, as in their other products, Dunlop leaves nothing to chance, for in order to compare their own with other people's boards they have constructed a machine which fires dart points into boards under test at the frightening rate of 72,000 per hour. It will be understood that a board which will stand some three hours of this treatment within the area of a few square inches will probably succeed in enduring the worst extremities of clubs, canteens or licensed premises. Few competitive boards will stand up to the inhuman mechanical dart slinger for more than a matter of minutes; none outlive Dunlop's.

CHAPTER XV

DUNLOP OVERSEAS

IN Chapter I, I suggested some of the benefits which the Allied cause derived from the Dunlop factories overseas, particularly those in the British Dominions. Strategically the most important factories were those in India and South Africa.

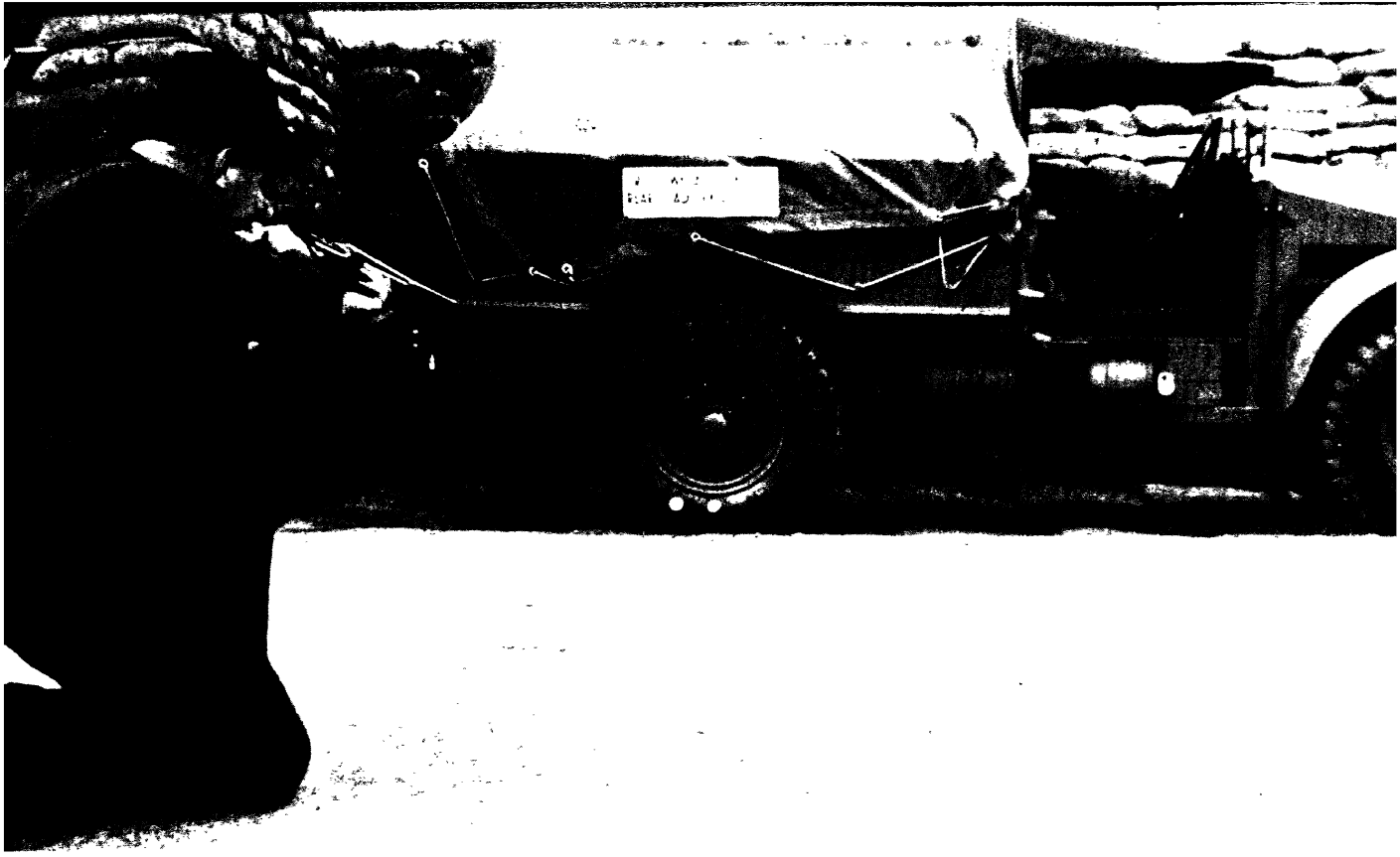
The effectiveness of these factories was much increased by the close system of intercommunication which had been built up between the Dunlop plants all over the world. This meant that all plants wherever situated had the full advantage of the whole Organization's research and technical development wherever carried out.

DUNLOP IN INDIA

The industrialization of a country of 440 million human beings, in every stage of economic and social development, is a terrifying problem. Yet the people of India, divided on so many other matters, are at least agreed on this: they want to raise the status of India's people and their standard of living.

Dunlop had been a pioneer in India's programme of industrialization so far as the rubber industry was concerned. In 1936 the Company decided to have a factory there, and was able to secure a suitable site and buildings at Sahagunj, a drowsy little Bengal village about 30 miles north of Calcutta. The necessary adaptations and equipment were rapidly completed and before long Sahagunj was despatching Dunlop products made in India by road, rail and river to every corner of the great sub-continent. When war broke out in 1939 the plant, under the management of Mr. F. F. M. Ferguson, was employing 1,200 workers and was turning out each year 200,000 truck and motor car covers and tubes, well over 1,000,000 cycle tyre covers and tubes, and was mixing annually more than 11,000,000 pounds of raw rubber. In the months and years that were to follow, in the black days of 1940 and in the critical period that ensued after Japan's treacherous attack on Malaya and Burma, the existence of this factory was a great source of comfort to the Government of India. It provided munitions of war that were essential to the defence of India, and when the time came, a large part of the equipment which helped India to hit back. It was of notable assistance to the British and Allied military commanders in the Middle East and in South-East Asia, and gave just pride to the Organization at home.

When the crisis came, it was natural that the Indian Government should look immediately to Dunlop for assistance in dealing with the



monstration of "Runflat" tyres to officials of the Ministry of [illegible]

Left: The underwater swimsuit of the "Frogman" is a second skin of supple rubber. His streamlined breathing apparatus enables him to work under water for considerable periods, and the "swim-fins" give him the speed of a racing champion.

Above: A "Frogman" dressed and waiting at the ready, can scramble into the water in less than 30 seconds.

(See Chapter XII.)

various problems in relation to Rubber Control and the organization of transport. Mr. J. P. Anderson, the Sales Manager, was lent to the Government to act as Rubber Controller, and every form of non-essential production was, of course, immediately suspended. Sixty per cent of the European members of the Company left forthwith to join the Forces. Many Indian employees who wanted to volunteer for the Army were also released, thus intensifying the need for training competent substitutes at the moment when, on the urgent request of the Government of India, an expansion programme on a grand scale was put into operation. Assembling new plant and training new workers from utterly inexperienced material was a very different thing from what it would have been in Britain or America. The factory operated 24 hours a day throughout the war period, and the strain on the European staff, owing to climatic conditions—the ceaseless heavy damp heat in that part of India—was severe. The managerial problems were tough—sometimes heartbreaking. War risks accentuated these problems. The new expansion involved the large-scale shipment of plant and equipment from the United Kingdom and three times vital parts were lost at sea as a result of enemy action; but finally perseverance achieved its purpose, and the expanded plant was in operation. To balance the disadvantage of being so far removed from its sources of supply for machinery and equipment, the factory enjoyed the inestimable advantage of being able to draw practically all its supplies of rubber and cotton from Indian plantations. This proved of immense value when Malaya and Java were lost to the Allies. On VE Day Sahagunj was employing 5,500 workers, had more than doubled its output of car and lorry tyres for Army vehicles and vital civil services, was producing 3,000,000 cycle covers and tubes, and in addition was supplying the British and American Air Forces with a huge quantity of aero covers and tubes. Altogether the factory's output at this time was nearly four times what it had been in 1939.

As was to be expected, the existence of this great war industry did not escape the attention of the Japanese. At about 10 o'clock on the night of 15th January, 1943, three Japanese bombers attacked from a low level and dropped 12 bombs in and around the Company's property. Fortunately their aim was faulty, although not by a wide margin, and the factory escaped without damage. But one bomb dropped on a block of operatives' quarters, where ten men were killed and about 20 injured. The three raiders were shot down within five minutes of the raid, and the Flying Officer who accomplished this feat received a well-merited decoration. The interruption of the factory's activity was only temporary and, had not the Far Eastern war collapsed so rapidly, its contribution to the Allied victory would have been even greater.

DUNLOP IN SOUTH AFRICA

The course of the war soon proved the military importance of South Africa. This first became apparent with the virtual closing of the

Mediterranean by enemy submarines, but it was greatly accentuated when Singapore and the Dutch East Indies were lost. The deflection of the Australian war effort to the Pacific theatre rendered South Africa strategically vital.

With the loss of Java, Sumatra and Malaya, rubber became such a valuable commodity that it was logical to have as much as possible treated in Durban (where Dunlop South Africa Limited has its plant)—right on the one remaining sea lane to the East and Middle East—rather than to subject it to the double hazard of a voyage to Europe or America as raw material and back again in the form of finished products. Dunlop therefore decided at an early stage to allot to Durban all that it could use of the rubber available.

The speeding up of the production of the Durban factory was remarkable. In 1938 it had a normal capacity of 30,000 giant covers. This output was increased so rapidly that the actual output of the factory at the war's end comprised the following production for direct military purposes:

Car tyres, including animal-drawn vehicle and motor cycle	121,814
Giant tyres, including tractor	209,705
Aero tyres	46,304

This remarkable record at Durban was accompanied by a general expansion of other products by the factory. In 1942 the manufacture of tyres for aircraft, not hitherto made in Durban, was begun and some thousands of these were supplied to the Allied Forces. The production of tubes kept pace with the production of covers. Many thousands of yards of rubbered fabric were made for de-Gaussing ships, a process that was carried out to the greatest possible extent in Durban and other South African ports. Inflatable dinghies were produced, as well as a number of special articles asked for by the Army and the Navy.

An interesting and unforeseen result of hostilities was that the Durban factory found itself designing and manufacturing tyres for German aeroplanes, because the South African Air Force at the start of the war was equipped with Junkers which had been obtained by barter of South African wool. There was no stock of spares available and the Durban factory had to supply them. They never failed the Air Force, and the Junkers pursued their strangely congenial task of anti-Nazi coastal patrol for a long time after war started.

When natural rubber became short a great hunt ensued all over the continent of Africa for alternative sources of supply. In South Africa itself about half the indigenous bushes will exude a white sap when broken. The publicity associated with the hunt for rubber was so great that almost every man in the country was convinced that he had found the needed source; and experts spent much precious time explaining to him that unfortunately he had not.

Much work was done at Durban on reclaim, and the material handled came all the way up and down Africa from the coast of Tripoli southwards. This work, to which every line of communication and every battlefield yielded its quota, was carried out by means of bakers' ovens specially improvised.

One of the problems at Durban was that of dealing with rubber salved from the sea; this was comparable with the problems of the Dunlop Irish factory at Cork, mentioned later in this chapter. Thousands of bales of rubber from torpedoed ships eventually reached the sandy coasts of Africa. Often these had been in the water for weeks, were waterlogged, and had also picked up large quantities of sand while tumbling in the surf. It was remarked at the Durban factory that even the fish seemed to have turned Nazi, because a number of the salved bales were found to have been pierced with the broken-off "swords" or snouts of swordfish which had attacked the bales while they were floating in the ocean. All of this rubber, as well as the variegated lots of wild African rubber purchased from various sources, had to be stripped, washed and dried: a tedious but unavoidable task.

Another of the war-time difficulties at the Durban factory concerned the textiles used for its production. Before the war all cotton textiles used in the South African plant came from the Dunlop Cotton Mills at Rochdale and answered to standard specifications. During the war they had to be bought in the United States, Canada, and many other places. This resulted in a great variation in tensile strengths, which added teasingly to the work of ensuring even quality.

Staffing troubles at Durban, owing to the volunteering or calling-up of employees, rivalled those of Dunlop units elsewhere. The process began at the top, for Sir Brian Robertson, the managing director, was on the outbreak of war called to an important military post leaving Mr. T. E. Peppercorn as his successor. Only about a third of the employees were of European descent—a cause of further complications. Of the Europeans, 309 joined various branches of the Forces: 293 men and 16 women. Casualties were five killed, one dead of wounds, one missing believed killed, 13 wounded and 28 prisoners of war. Some were blown up on land, others torpedoed at sea, lost in the desert, or adrift in the ocean. One was afloat in a shark-infested sea for 29 hours. Another drifted for nine days. A third wandered for nine days in the desert. All three came through safe and sound.

DUNLOP IN AUSTRALIA

The war-time achievements of Dunlop Rubber Australia Limited were, as would be expected from the people and business institutions of that great Dominion, on a tremendous scale. No Dunlop Company overseas was so wholly thrown upon its own skill and resources for a long period of time as the Australian Company, the Chairman of which

was that eminent Australian, the late Hon. W. A. Watt, while Mr. W. A. Bartlett, who has recently succeeded Mr. Watt as Chairman, was General Manager.

The rubber manufacturing plants in Melbourne and Sydney and the clothing factory at Wagga had to engage in the manufacture of many war products which they had never before attempted, to start from scratch and even to design and manufacture the machinery for the purpose. As in England, this called for the almost complete cessation of work on all products not directly connected with the Dominion war effort or the vast munitions programme.

During the early part of the war the Australian contribution was mainly concerned with equipping the Australian Divisions which had so brilliant a record in the Middle East and North Africa, as well as those which went to Malaya. The bulk of this equipment consisted of motor car, truck and aeroplane tyres and tubes, including bullet-proof tyres.

When Japan entered the war, in December 1941, the outlook for Australia and for the Dunlop organization there was, as the world quickly realized, a grim one. Australia at once became the base from which the Allied Forces were to advance in the greatest long-distance naval and military effort in the history of the world.

The first operating problem which confronted the Company after Pearl Harbour was to begin mass production of a great variety of tyres and other military equipment for the United States Army, which within comparatively few months had a million men in the Dominion with a voracious need for supplies of all kinds, but particularly and inexorably things made of rubber which, with food and explosives, made up the triad that won the war. Many of the American sizes had never been made in Australia and frequent improvisation was necessary. At one time in the dark days of early 1942 truck-type tyres had to be fitted to aircraft to keep urgently needed operational planes in the air.

In all more than three-quarters of a million tyres were made, ranging up to the huge 18-ply tyres for the earth-moving machines which built air strips in Australia and on many Pacific Islands, and the 47 inch tyres for the larger American bomber planes. To have obtained manufacturing plant from England or the United States would have entailed a long delay which could not be tolerated, added to which was the risk of being torpedoed by Japanese submarines. In this emergency the Dunlop Australian factories speedily built the necessary machinery in their own engineering departments. This indeed is the usual Dunlop custom in England, but it was a new and very different problem for plants which at that period were "thousands of miles from nowhere." This machinery, constructed on the spot, played a vital part in the swift momentum which the Allied war effort in the Pacific so soon attained.

The products of the Australian factories largely duplicated those turned out in England and already described in this volume. But there

were quite a number of items made in Australia which were unique in that part of the world, although they were not unknown in Europe. One of the most interesting and novel of these was the salvage camel mentioned on page 52. These camels were very large rubberized air pressure bags able to raise sunken ships, when inflated. The uninflated camels were placed in position by divers, the suits for whom were also made by Dunlop, and as the camels were inflated both ship and camels floated to the surface. Using the same principle, smaller camels were made for raising aircraft which had fallen into the sea. These camels never failed to impress laymen, and even experienced engineers, with the immense and always surprising power of pneumatic equipment.

Allied submarines in the Pacific suffered a good deal from the shock of depth charges. Dunlop Australian engineers developed a specially designed ebonite battery cell which successfully resisted these shocks, and kept the submarines from periods of inactivity enforced by repairs.

An unusual operation was carried out by Dunlop engineers on the Dutch cruiser *Van Trompf*, which had escaped to Australian waters. The propeller shaft of the cruiser was covered *in situ* with rubber (to provide a water-lubricated bearing), and a very ingenious arrangement of the recently developed infra-red heating units was used for vulcanizing the rubber covering while the ship was in dry dock.

The complex construction of naval torpedoes is generally known. A large number of parts were made by Dunlop, one type calling for 25 different mouldings in ebonite. Machine gun belts, too, were an important Service contribution. A large sub-department of the factory was engaged entirely on the assembly of Vickers .303 machine gun belts from webbing and metal fittings supplied. This work called for special machines hitherto unknown in Australia, and these were manufactured in the machine shop of the engineering department.

An example of the rapid conversion of peace-time appliances to war work was given by the woodworking departments which had formerly manufactured such products as theatre chairs, etc. These produced a large number of plywood landing-boats which were used all over the Pacific area of operations. The fittings for these boats—anchor chains, rowlocks and sliding-seats—were made in the Dunlop machine shops.

The footwear departments operated at a high speed throughout the war, and one of their products is of strange, ironic interest. This was a waterproof patrol boot with a separate great toe compartment, leaving a print in the sand similar to that left by the Japanese army sandshoes. The Japanese were thus tricked into believing that tracks left by Allied soldiers on patrol had been made by their own forces.

The recurring differences between the British and American naval and military equipment in design, gauge, calibre and countless other ways, were a heavy burden and a drag on the speed of turning out equipment. This was particularly felt during the crucial months in the Pacific

when the need for shipping to finish the war in Europe demanded intensive use of every facility which could be locally employed in Australia. Very many British, Australian and American officers and enlisted men were then impressed with the enormous gain which would have accrued to the Allied war effort, shortening the war and saving thousands of Allied lives, if the war equipment of all the English-speaking peoples had from the first been co-ordinated and interchangeable. As it was, the Australian Dunlop Organization faced the double task with vigour and determination which resulted in a noble contribution to the war effort. Judged by population and resources, it can without exaggeration be called colossal.

DUNLOP IN CANADA

The Dunlop Tyre and Rubber Corporation of Toronto, Canada, occupied a key position between Britain and the United States. One of the main contributions of the many which the Company made to the war effort was in acting as a clearing-house between the British Dunlop Company and the Ministry of Supply on the one hand and the Canadian rubber manufacturers on the other in the production of "run-flat" and "cross-country" tyres. The Canadian Company made hundreds of thousands of these special tyres and a corresponding number of tubes. It also performed an invaluable service by manufacturing aeroplane tyres and tubes in British sizes for the training and operational planes in Canada and the United States, including all tyre equipment for the De Havilland Mosquito and the Victory Aircraft Lancaster.

The Canadian Company also had an intimate and essential connection with the production of the all-important Dunlop Brake and Gun Operating Equipment. There was no space in its own plant for the manufacture of these products; arrangements were therefore made with outside suppliers to manufacture to British specifications, and the Company, with the help of a technical engineer sent out from Coventry, supervised and were responsible for the production of all the Canadian output of this equipment. Similar arrangements were made with the Kelsey Wheel Company at Windsor, Ontario, to produce Dunlop wheels and brakes, and the Canadian Dunlop Company acted as a liaison between the Kelsey Company and the British Dunlop Company.

When hostilities ceased, the Canadian Dunlop Company had supplied or was supplying tubes and other equipment for the De Havilland Tiger Moth, Mosquito, Hawker Hurricane, Westland Lysander, Avro-Anson, Lancaster, Lincoln, Handley Page, Hampden, Bristol Bolingbroke, Fairey Battle, Airspeed Oxford and Vickers Stranraer.

One of the Company's greatest problems in manufacturing to British specifications was the impossibility of obtaining many materials which were needed to comply with the specifications laid down. A great deal of time and effort was devoted to testing and obtaining approval for alternative materials.

The Company's efforts were of necessity to some extent parallel with those of the British Company; and its co-operation in the production of the Franks Suit was particularly valuable since the original development work on this and many of the early models had been made at the Toronto plant; indeed, when Dr. Franks came to this country he carried a confidential introduction from the Canadian Company to Dunlop Works at Birmingham and Manchester, where, as I have already described, the further and final development work was completed and production established.

Dunlop, Canada, however, carried on some special activities which found no parallel in Britain: such as the development of a special type of goggle to enable men wearing glasses to pilot planes successfully. Other specifically Canadian achievements were numerous extruded parts in plastic materials for different war purposes, the special freeze-resistant compounds for the Royal Navy and the Canadian Navy, Army and Air Force, and the large quantity of fire hose which was of material assistance to the mother country in the Battle of Britain. In Canada, as elsewhere, the Government made a substantial call upon the time and abilities of Dunlop technical and administrative staff. Mr. J. J. Simpson, President of the Company, became Chairman of the Government's Rubber Advisory Committee, while other leading executives undertook responsible national work.

DUNLOP IN IRELAND

The elements of drama and unexpectedness in the World War were not monopolized by the Fighting Forces. There were activities of civilians also which called for great personal bravery, involved a large measure of luck, were highly remunerated when successful and from the economic point of view had great value both military and civilian. Among these was the recovery of bales of rubber from ships lost by enemy action off the coast of Ireland.

Literature teems with romantic stories about wreckage washed ashore from sunken ships, but it was left to this war to prove the importance of salvage in keeping a factory open and supplying badly needed manufactured goods. This was exemplified in the Dunlop factory at Cork, in Eire, though the process was complicated by the peculiar attitude of neutrality which that country chose to observe towards the struggle to save civilization.

For the first eighteen months of the war, the Irish Dunlop factory continued its operations with little difficulty. About the only change was from car tyres to tyres for commercial vehicles, made necessary by the rationing of petrol. Some surplus of commercial tyres was also supplied to Northern Ireland and to Britain.

The fall of Singapore and the increasing submarine losses darkened the horizon of the world—including Eire. For a time the Cork factory had to reduce operations and it soon had less than 100 tons of rubber

in reserve. It was then that the possible value of rubber saved from the sea was first fully appreciated.

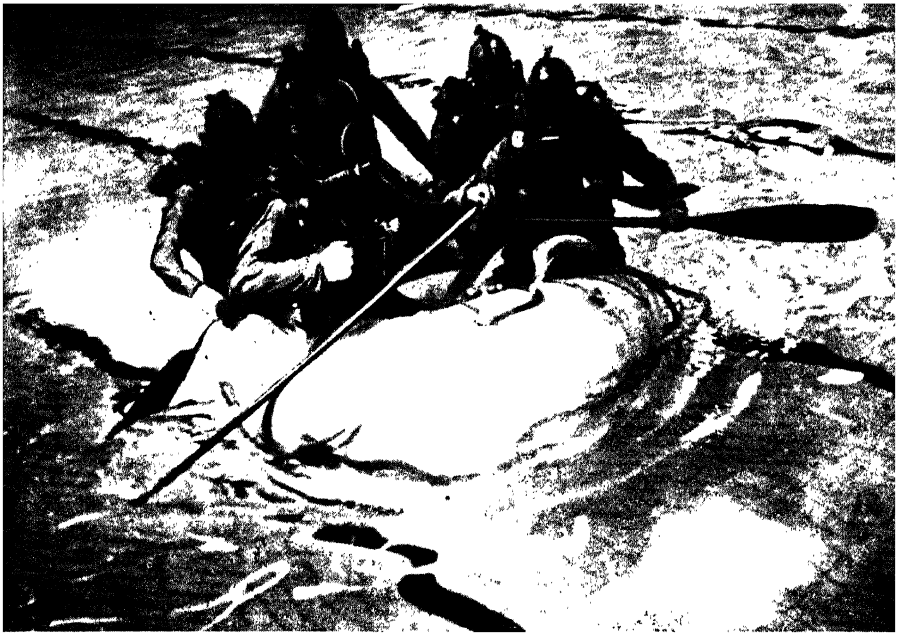
Dunlop officials at Cork began to hear reports of rubber being washed ashore as early as 1940, but these were not seriously considered as a possible source of raw material supplies until after the fall of Malaya. Many finders of rubber washed ashore from torpedoed ships had approached Dunlop officials, but under the law it had been necessary for these to refer such offers to the Receivers of Wrecks for the various districts of Eire. To advise these hardy fishermen and small farmers to hand over their salvaged rubber to public officials was like waving a red flag at a bull. They had risked their lives to salve the rubber off the wild and desolate coasts of North-Western Ireland and felt that they should get the last penny of profit out of such a gift from Heaven. The prices offered them by the Receivers of Wrecks were in fact a travesty of the real value of the rubber.

About this time Receivers of Wrecks were offering the Company appreciable amounts of rubber varying from 20 to 40 ton lots, and information was being published in local Irish papers of huge quantities of rubber coming ashore. There were also accounts of seizures, and of prosecutions which were instituted against those finders who had to surrender their salvage to the designated authorities. Meanwhile the Company's office at Cork was being inundated with offers from speculators willing to take a chance and buy rubber from salvors on the Company's behalf.

When in an attempt to make this badly needed rubber available to the Cork factory Dunlop officials approached the Eire Government, the regulations governing wreckage were found to be a tangle of red tape, dating back to Victorian and Georgian times, so that it was very difficult to make any progress.

However, immediately after Christmas 1941, a Dunlop buyer was instructed to make a tour of the coastal districts of Western Ireland and investigate the position. He found that many of the early stories were true, but that the salvors were extremely reluctant to hand over their rubber because of the absurdly low price offered by the authorities. He also found that the prosecutions had had the effect of deterring fishermen from risking their lives in the stormy waters off the coast for an enterprise which might well land them in gaol. The Dunlop buyer also found that salvors were highly reluctant even to discuss any rubber they had found until his own integrity had been vouched for by a local third party of good standing not connected with officialdom. Once confidence had been established the buyer was taken down dangerous cliffs by paths known only to local inhabitants, and shewn rubber stored in caves. Elsewhere he found it buried even in potato pits.

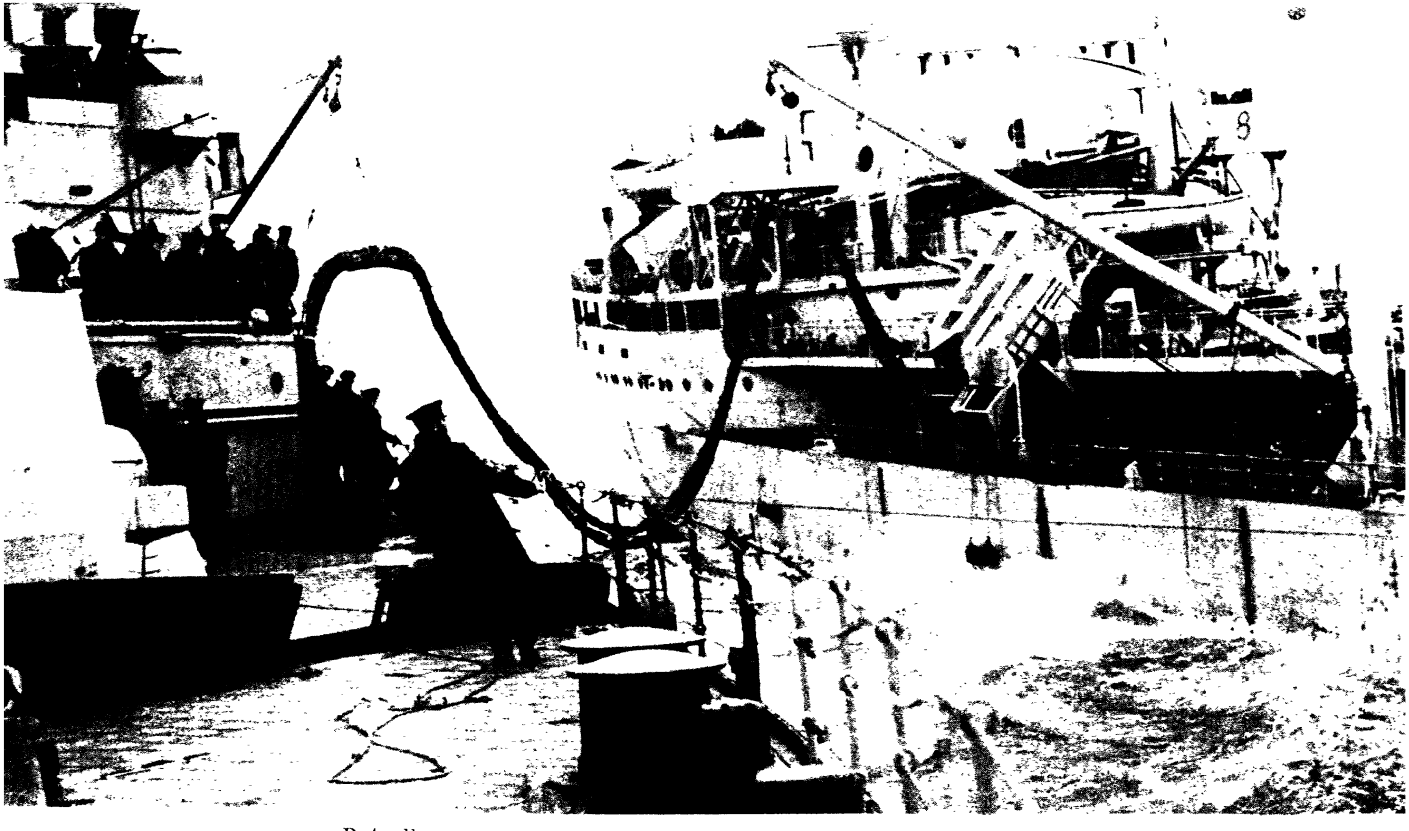
As a result of his tour the buyer returned to Cork with about fifty tons of rubber. This was greatly needed raw material, and the Company immediately reported the facts of the situation to the Eire officials.



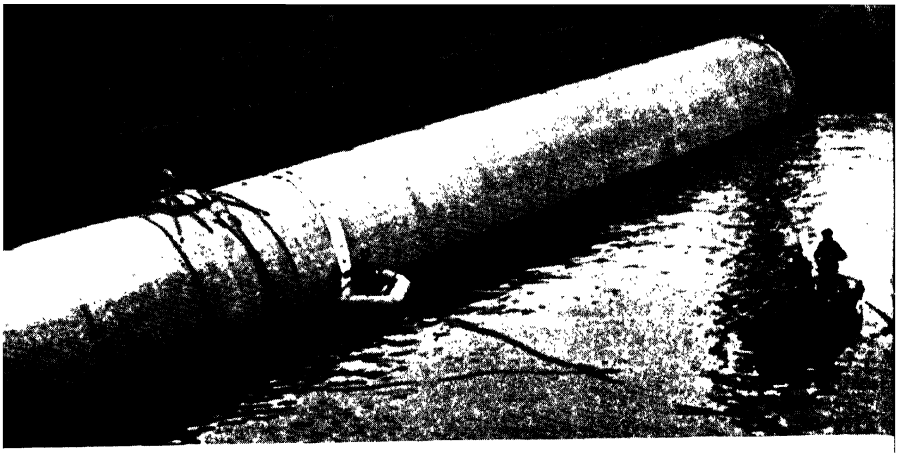
Above: The "Frogmen" can crash-dive and be out of the dinghy in a fifth of a second. (See Chapter XII.)

Below: "Frogmen" preparing to blow up a replica of one of the $2\frac{1}{2}$ tons, 10-feet high steel obstructions on which the enemy relied to stop Allied landings.

An inflatable decoy tank. Deflated, it can be packed in a container only slightly larger than a cricket-bag. (See Chapter XI.)



Refuelling at sea by means of Dunlop hose. (See Chapter XII.)



Above: The Admiralty wave controller, the largest individual device ever produced by the Rubber Industry throughout the world. The pneumatic part weighs nearly 11 tons.
(See Chapter XII.)

Below: Attaching leaflets to balloons for bombarding enemy lines.
(See Chapter XIV.)

These took a broadminded view of the matter and granted Dunlop full rights to collect all salvage rubber washed ashore on the Irish coasts. In addition, a press and wireless campaign was opened with astonishing results.

It was found impracticable for the Company to deal directly with the individual salvors all over the country, so with Government approval, the coastal areas were divided into districts and about fifty sub-collectors were appointed. These were men of good local standing, in a position to purchase and pay for rubber on the spot, and the system assured prompt delivery of the rubber to the factory at Cork. These sub-collectors have come to be known as the Irish Company's "Rubber Plantation-Managers."

People living inland have little conception of the hazardous nature of rescuing these heavy 2-cwt bales from a stormy sea. Most of the rubber is blown inland towards the rocky shores between September and the end of April. The period covers the equinoctial gales and the stormy weather of early spring; two lives, at least, are known to have been lost in this desperate work. Instances have been reported where fishermen have stood on high cliffs and watched 40 or 50 bales churning in a raging sea during a gale. In such circumstances salvage operations cannot be started until the gale abates. Often when daylight appeared the watchers found the rubber gone and their reward of £300 to £400—a fortune on the West Coast of Ireland—gone with it.

When the rubber first began to be washed ashore many simple country folk had no idea what it was, and occasions are known where it has been used to light fires. But the coastal population is now well aware of its value, as well as of the fact that the Irish Dunlop Company are the sole lawful buyers.

The arrangements between the Company and the Eire Government worked smoothly throughout, and were so interpreted that the Government's conception of neutrality was punctiliously observed. It was agreed that the Cork factory should operate at full capacity and that 80 per cent of the finished output should be sent to England. The tyres exported from Ireland were all civilian transport tyres, but their arrival permitted more labour and plant in the factories in England to concentrate on tyres for the Fighting Services.

Although Mr. B. J. O'Donnell, the Works Manager, was released early in the war to undertake important work for the British Ministry o Supply, the Cork Factory continued, under the management of Mr. R. C. Flanagan, to operate very successfully, and exported more than three-quarters of a million motor covers and tubes and two and a half million cycle covers and tubes to England and Northern Ireland. The balance was used in Eire solely on essential vehicles, many of which were engaged in the transport of cattle and foodstuffs from the farms to the ports for export to England.

DUNLOP IN THE UNITED STATES

The largest of all the Dunlop overseas factories belongs to the Dunlop Tire and Rubber Corporation of Buffalo, and this factory was of course able to make a substantial direct contribution to the equipment of the American Forces. Its main war product was tires (to use the American spelling) and these were supplied in large volume both for land and air. But the Company's best-known achievement was the large number of airships, popularly known as blimps, provided for the United States Navy.

American naval authorities attached great value to the blimps in the measures which they took to fight the German submarine menace on the American Atlantic seaboard and in the Gulf of Mexico. The blimps were cigar-shaped, with a length of 256 feet and a diameter 54 feet. They were inflated with 240,000 cubic feet of non-inflammable and non-explosive helium gas, of which the only known commercial supply is in Texas.

These airships had a speed when needed of about 80 miles per hour, but, unlike the aeroplane, they had also the power of remaining almost stationary in the air when necessary. In areas where submarines were suspected of lurking, this was a valuable quality. Visibility around the American coast is, in general, very much clearer than in Europe, and comparatively few blimps were able to mount guard over an immense span of ocean.

The war output of the American factory was enormous. It produced more than 22,000 tons of motor vehicle tires for various war services, and 800,000 square yards of coated fabrics for use in the construction of boats, pontoons and airships. It also played a large part in the pneumatic decoy programme, making imitation landing barges and other items of war equipment with which to confuse and delude the enemy.

The President of the Company, Mr. E. B. Germain, who before his entry into the Rubber industry had had wide experience in the American shipbuilding yards, rendered an important service to the Allied cause by becoming President and Manager of an official company formed by the United States Government to build and operate a large fleet of small cargo boats.

BRAZIL

One of the strangest industrial episodes of the war concerns the Dunlop Organization in Brazil. That great country is, as everyone knows (it is related elsewhere in this book), the original home of the rubber plant. For a long time, however, the rubber used in Brazil had been plantation rubber from Malaya. The collection of wild rubber from the Amazonian basin had, for all practical purposes, almost ceased.

During the first few months of the war, the Dunlop Organization in Brazil continued to push the sale of tyres and other goods imported

from Britain, thus bearing its share in the export drive then maintained to keep as much British trade as possible in being. When, in the latter months of 1940, imports from Britain were brought virtually to a standstill, the local Organization was nevertheless able to obtain supplies from a local source and thereby to maintain its position in the market.

When the Japanese successes led to the cessation of natural rubber supplies from Malaya, the wild rubber resources of the Amazon jungles suddenly soared to an importance they had not known for many years. The price soared also. Brazil, being a producer of both cotton and rubber, seemed ideally situated to continue the manufacture of tyres and other rubber articles, untroubled by the disasters which were wrecking the rest of the world. At this juncture the United States fell extremely short of natural rubber and began to look for alternative sources to carry on its stupendous war effort. An agreement was made between the United States and Brazilian Government under which the Rubber Development Corporation (an American Government-sponsored organization then known as the Rubber Reserve Company) undertook to organize and develop the collection of wild rubber in the Brazilian producing area. The Corporation undertook to buy all Brazilian rubber other than that needed by the Brazilian domestic industry at an advantageous price for a number of years ahead. Moreover, the United States also undertook to buy all tyres and other rubber goods which could be produced in Brazil beyond the needs of the domestic market. These were distributed in the United States and in other South American countries.

The situation resulted in a period of great activity for the Brazilian rubber manufacturing industry. There was considerable expansion of factory space, and though wild rubber became four times as dear as plantation rubber had formerly been, while cotton and labour costs mounted with it, the Dunlop Organization was able to make an excellent showing.

In 1944 Brazilian rubber manufacturers were to experience the full turn of the wheel, first from plantation to wild, and finally from wild to synthetic rubber from American sources. When stocks of plantation rubber sank dangerously low in the United States in 1944, Brazil was asked to import synthetic from the States, thus releasing a considerable supply of natural rubber for vitally important war purposes.

The Brazilian tyre industry co-operated loyally in this Allied war effort. Their factories began preparations to use synthetic in January 1945, and by April were turning out practically all covers, both giant and passenger, with 100 per cent synthetic treads. This latest exemplification of the ancient paradox—carrying olives to Athens, coals to Newcastle, whisky to Scotland—proved entirely successful, and it helped to keep the name of Dunlop before tyre users in several South American countries during the world's greatest crisis.

DUNLOP IN FRANCE

At the outbreak of the war in 1939, Dunlop interests in France were large and of great importance to the French military effort. The French Company—the *Société des Pneumatiques Dunlop*—produced 36 per cent of all the tyres used in France. Moreover it had a positive superiority over all others in giant tyres and aeroplane tyres, which greatly enhanced its value for all conceivable military contingencies.

Therefore the fall of France, and the division of the country into the so-called Occupied and Unoccupied zones, confronted the French Dunlop management with a situation of great complexity and danger. Their first move was to transfer the head office from Paris to the factory at Montlucon, a town in the Unoccupied zone not far from Vichy, with the object of getting as far away as possible from the centre of German military authority.

Six postulates were then progressively adopted as a basis of policy and of action:—

(1) It was of course impossible to stop the manufacture of tyres in the Dunlop factory. To do so would have added further injury to the already cracking French economy, and there would probably have been, as was so often threatened, mass deportation of staff and operatives alike to infinitely worse conditions in Germany.

(2) Exports of Dunlop products to Germany must be restricted in every possible way, and although this restriction could not be absolute, at least the products of the French factory should be sent as far as practicable to the German Dunlop factory at Hanau, because of the friendly relations which had been built up over many years by the workers in the two plants.

(3) Every practicable step was taken to delay production when (towards the end of 1941) natural rubber supplies had been exhausted and the Germans forced French tyre factories to switch over to the use of Buna. Negotiations regarding Buna were dragged out to the greatest possible length, and the Germans were never able to obtain from the factory the quantity of tyres they expected and needed.

(4) After the Dunlop French factory had been bombed by the Allies on 16th September, 1943, every effort was made to prevent the remaining plant and its operatives from being sent to Germany, as the German command wished.

(5) Every conceivable method was adopted to conceal raw material and to make sure that the largest quantity of finished goods reached the French home market instead of assisting the German war effort. This was done so successfully that at least half of the factory's production never reached the Occupying Authority.

(6) The work of reconstructing the bombed factory was so conducted that giant tyres, in which the Germans were most interested, could not be produced until the end of the war. On the other hand the cycle tyres which were destined solely for the French home market were finished and delivered in the shortest possible time.

After the factory had been bombed (the first bomb actually being dropped by a Dunlop employee) the Germans, apparently still confident of eventual victory, allocated thousands of tons of steel, cement and other materials for the rebuilding of the plant. Despite the presence, from the beginning, of German commissars permanently in the Dunlop offices, despite every German endeavour to get the tyre factory again into production, only seventy-two giant tyres and a few tubes—about half a normal peace-time day's work—were delivered to the enemy in the 11 or 12 months between the bombing and the day of liberation.

The Germans had various ways of dealing with the French industries which they forced to work for them. Where the industry was French-owned the existing management was usually left more or less alone but closely watched to see that output was maintained. Most French companies accepted the situation with as good grace as possible; because it was obvious that if they had refused, their employees would have been deported as slave labour to Germany, families would have been broken up, and an already bad situation would have been multiplied in grief, starvation and misery.

Where it was known that foreign capital had been invested in a company, particularly if it was British or American, the Germans pursued different tactics. Dunlop, of course, was known by everybody to have emanated from the parent company in Great Britain, and was therefore an obvious target for Nazi attention. Soon after the fall of France a Nazi commissar was appointed for the factory. He was a typical German "Ox-Head" and as he knew little about the rubber business he was unable to cause much trouble for the management.

Later on a Berlin bank manager who was not a Nazi was appointed to the post. He acted reasonably and did not give much cause for complaint, nor (which was more important) did he ever find out much that was going on. On the whole, the managers of the Dunlop enterprise in France proved more than a match for the Hun barbarians who assumed, for a time, that they would turn the lovely land of France into a German province.

In recognition of its great services to the Allied cause an unusual distinction was awarded by the Government of the United States to the French Dunlop works at Montlucon. This was the coveted Pennant "A," which was won by a number of American and Canadian firms, and a very few elsewhere, for their industrial contributions to the joint war effort. The award was celebrated by a moving ceremony at the Mont-

lucon works on 7th November, 1945, when detachments of the American Army joined with the men and women of French Dunlop in commemorating their joint efforts to free France of the invader.

In the centre of the works, surrounding the monument erected to the memory of J. B. Dunlop, founder of the tyre industry, the whole personnel was present to welcome the American delegation accompanied by French military and civilian authorities. One after the other, the American and the French flags were hoisted. The national anthem rang out; the pennant which will henceforth symbolize the co-operation of the Dunlop Works in the Allied war effort was hoisted between the colours of the two friendly nations. Detachments from the American Army and from the French Army marched past watched by the quiet crowd.

After the salute to the Colours, Lieut.-Colonel Holle made a short speech which went straight to the hearts of his listeners. Much moved, M. Furet, head of the Works, spoke on behalf of the whole personnel, thanking our Allies for the high honour which had been awarded, and conveying the gratitude of the French towards the American nation.

The "Pennant for Merit" was lowered from the flagstaff, Lieut.-Colonel Holle presented it to the Dunlop Works, while a factory girl approached the American officer and offered him the flowers which, with the traditional kiss, set the seal on the understanding which had never ceased to exist between the victorious army and the men who had contributed to the equipment of the liberating armies. The military detachments, amid continuous applause, marched past for the last time, making their way through an enthusiastic crowd.

In commemoration of this memorable event, every year henceforward on 7th November the Pennant for Merit will fly above the Dunlop Works at Montlucon.

CHAPTER XVI

EXPERIENCES OF DUNLOP OFFICIALS IN ESCAPING FROM THE JAPANESE AND SOME OF THE SUFFERINGS ENDURED DURING INTERNMENT

IN surveying the great contribution which the overseas Dunlop Organization made to the Allied cause, it is but right to refer to the sufferings and adventures of their employees who fell, or almost fell, into Japanese hands in the Far East.

This chapter therefore relates some facts concerning Dunlop men involved in the Japanese advance and occupation of Malaya and other parts of the Far East. The personal experiences of a few, told in their own words, give a more vivid idea of what happened to these and other men and women who were involved in this great disaster than could any account compiled second-hand.

These personal descriptions of what happened to individuals show that the traditional self-reliance of the British is as great to-day as ever. They shew too, of what great value their Dunlop connexion was to these fugitives by land and sea. When every sort of organized public service broke down, and promised relief failed to arrive, these men stood by each other and defied fate to destroy them. Only after years of starvation did self-control sometimes break down.

The following account of his experiences is given in his own words by Mr. D. W. Hawkins, Production Manager for the Dunlop Malayan Estates Company:—

"Throughout the battle of Malaya and Singapore confusion reigned so far as the civil population was concerned. During 1940 and 1941 they had been told from the platform, by the radio and through the Press that the country was more than adequately defended and in fact the Japanese were more or less challenged to try their luck. The attack when it came was not, therefore, expected to succeed and the position was viewed with quiet confidence by the people living in the peninsula. The stream of refugees from Penang and other northern towns told of chaos and of bombing and machine gunning, but no one knew what was really happening.

"On 8th January, 1942, the Board of Dunlop Malayan Estates Ltd. met in Malacca, and decided as a precautionary measure to send the Company's books and principal records to Singapore. We had no

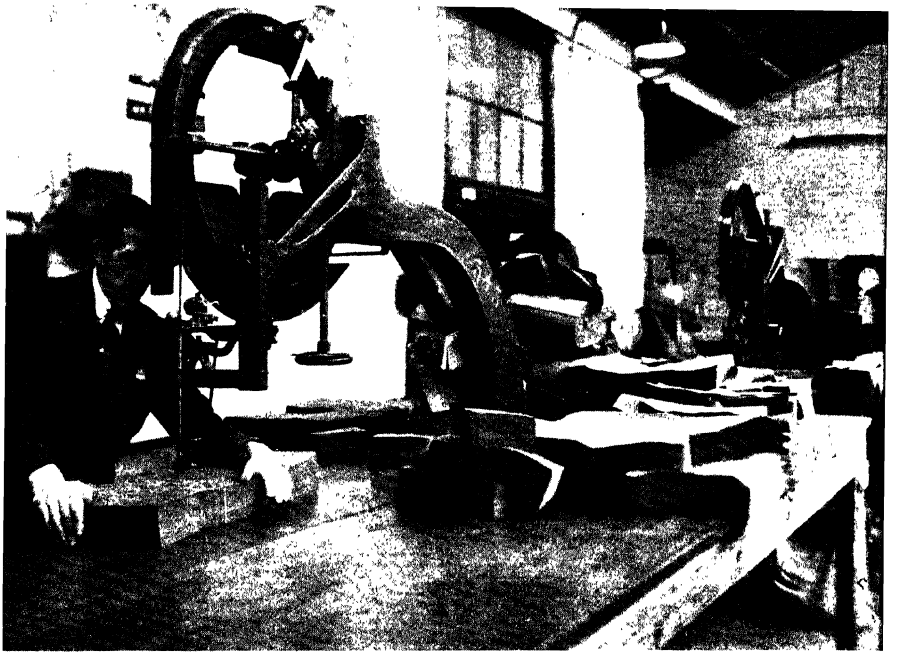
information other than the official news which was that the Japanese were being held some twenty or thirty miles north of Kuala Lampur, a further hundred miles north of Malacca. At midday on Saturday, however, we were told by the Resident to close the office at once and to be out of the town by dawn the following day. This we did and the Japanese were in Malacca shortly afterwards.

"On Thursday, 12th February, Singapore was a most depressing sight and an even more depressing thought. The Japanese had landed on the island and were within a few miles of the centre of the town itself. A huge pall of black smoke from burning oil stores hung in the sky and completely obscured the sun. What was left of the Navy had sailed away. The R.A.F. was nowhere to be seen and as the result of unopposed air attack the docks were ablaze and telephone and trolley-bus wires covered the roads in hopeless entanglement. The civilian population, both European and Asiatic, had been gradually driven into the centre of the town, and I with a number of other Dunlop men had taken refuge in a large commercial building on the quay. We had all been doing various jobs, such as handling transport, but these had come to a forceful end. When we decided to attempt to reach Sumatra in a small boat the proposal was looked upon by most of our friends as a most foolhardy and unnecessary enterprise. At that time the current rumours were that an American force had landed at Penang and that General Wavell had promised reinforcements in three days. We were near giving up the idea when we met a Chinese fisherman who offered to sell us his *tongkang* and take us to the island of Tanjong Bali for the sum of $250.

"Later that night we met the fisherman as arranged and went on board his boat: quite a strong little craft and just large enough to hold the five of us and the Chinese. We fumbled about in the dark and in about an hour we were all ready to go but the fisherman was nowhere to be found. We waited all night. With dawn we saw that we were tied up to a small motor boat. We pulled it over and there he was with another man lying in the bows drugged with opium. These two took a lot of rousing. They then refused to move until they had made and slowly drunk some Chinese tea. We were to be towed as far as Tanjong Bali, after which we could carry on by ourselves in our *tongkang*, using oars and sail. The two old Chinese started up their motor boat. It made a most appalling noise and we thought that every Japanese gun within range must open up on us.

"When we reached Tanjong Bali, which is a small Dutch island between Singapore and Sumatra, the District Officer, a young Dutchman, came down to the small landing stage and told us in English that the Japanese would arrive at any moment to take over the island and that we had better make for the Indragiri River in Sumatra and proceed up it to the town of Renggat right away, and if we could follow it we should be all right. He then gave us a whisky and soda each, wished us the best of luck and after thanking him we set off after his launch.

The Edmonton clothing factory after the enemy rocket bomb attack. (See Chapter XIII.)



Above: A multiple cutter in use at the Edmonton clothing factory.

Below: The conveyor belt system is among the up-to-date methods used at the factory.
(See Chapter XIII.)

"Our fishermen soon contrived to lose the Dutch launch in the growing darkness. We had to tie up under the overhanging trees of an island, and spent a miserable night being eaten by mosquitoes and hundreds of other insects.

"We went on until at midday we ran into a channel between two small Dutch islands and tied up at the landing stage of a fair-sized village. Our fishermen decided to leave us and we paid them the balance of the price of the boat and off they went to buy wine in the village. We also decided to replenish our stores and, leaving a guard to look after the boat, we set off to do some shopping. When we got back the Dutch police said that our fishermen were already drunk on rice wine and they would not be allowed to stay on the island: we should have to take them with us. The native population had been friendly and helpful. One of the Headmen of the village had given us directions for Indragiri River and an introduction to the head man of the village of Prigit Raja at its mouth.

"Next morning we set off taking with us the fishermen (both suffering from a terrific hangover and very sulky and quarrelsome). We sailed all day and reached Sumatra in the evening, to find that we were many miles above the Indragiri; and we had to spend another night tied up at the mercy of the insects.

"The fishermen were giving a lot of trouble and we had to keep guard all night in case they tried to cut us adrift. In the morning we decided to part with them, gave them the *tongkang* and took the motor boat ourselves down the coast in search of the Indragiri River. Just after midday we sighted what we thought was our goal: a wide inlet to a small village but were informed by the inhabitants that the Indragiri was still farther down the coast. The people were very helpful and warned us that Japanese planes were constantly over and that many small boats had been machine-gunned and sunk. They advised us strongly not to make this journey and offered to guide us through inland waterways which would bring us to the mouth of the Indragiri. We arranged to pay for this service out of our meagre store of money, and it was agreed that we should start at once.

"Before we left we visited the village barber's shop and were shaved by a Javanese girl with a huge cut-throat razor: the most painful operation I have ever experienced, but we all felt fresher and brighter for it.

"Our guides then took us inland for many miles up a stream, narrower and narrower until it seemed that we must soon stick in the mud. The jungle closed in from both sides and hung down over the boat; there was practically no light and it was like going through a tunnel. At last, however, we swung into a wider and fast-moving stream which soon brought us out to the sea. We tied up for another night of insect bites and were glad to see the dawn and the mouth of the Indragiri River on the other side of a small bay.

"We proceeded to the village of Prigit Raja (Kings Well) and

presented our letter of introduction to the Headman. We were made very welcome and all clattered down the main street—built on stilts over the water—to an Indian eating-house where we were given a meal of curried duck and beer. The Headman ate and drank with us and before we left he insisted on being presented with a pair of binoculars which one of us carried. He said he wanted a memento of our visit.

"We then went on up the river for about ten miles until we came to a small town called Tembilahan, when we met a fairly large party of British troops in charge of an officer. The river at this point is very wide and in normal times large craft ply up and down it to the port of Rengatt. The officer had obtained the use of a huge wooden river boat and offered to take us with his men to Rengatt. It was noon the following day before we reached our destination.

"Rengatt is a fairly large town; we found a number of refugees assembled from various points. We went straight to the Dutch bank and changed our rapidly dwindling store of Straits' dollars into guilders. Shortly afterwards all banks refused to accept Straits' currency, so we were lucky. We then went to see the Dutch Authorities to obtain transport to Padang on the other side of Sumatra, where we hoped to get a ship to India or Australia. We were doomed to disappointment. They said that the military had taken all transport and petrol but that a camp had been started for refugees on a rubber plantation at Ayer Molek twenty miles away, and we should be taken there the following day. We slept on the floor of the rest house—at least we lay down; millions of mosquitoes bit us even through our clothes, and by morning we were red and swollen.

"The next day we were taken in lorries to Ayer Molek and allotted space in a rubber-packing shed. We collected sheets of crêpe rubber to make beds and lived there in comparative comfort for the next seven days. There was plenty of water and we had a bath in a rubber coagulating tank: our first since we left Singapore. We took it in turns to cook and serve the food and used old tins and rubber-tapping cups.

"At length we were taken by lorry to the town of Sawaloento. This journey took us all day and we were grateful indeed when we found that the authorities had ready for us a hot meal of soup and bread and that they had covered the floor of a large barn with straw so that we could sleep. Few of us remembered anything more until we were roused at 4 a.m. to catch the train to Padang.

"Padang is a small port on the west coast of Sumatra; The harbour had been heavily bombed by the Japanese and all shipping had fled. The Japanese had landed on the island and the inhabitants had resigned themselves to occupation and probable internment.

"We went to report to the local authorities. The Burgomaster was kind and offered us drinks and cigarettes and clothing. We were allotted billets and were told to go to the addresses and to present the official note provided.

"At my billet there was no one at home, but the Javanese boy seemed to expect me and I went off to meet our party at the British Consulate; relying on the British Consul to help us with money, expecting that he would make arrangements for evacuation. He was worried and extremely curt. He had no money; for evacuation we might try the military, or perhaps the Dutch shipping lines. It would not be possible to ring up Batavia nor would it be possible to send a cable direct from Padang as that would inform the enemy that there were refugees in the town.

"We returned to our billets and there I met my host and hostess, who gave me a very warm welcome. Their name was Kahle, from Rotterdam. Mr. Kahle could speak English and we were able to carry on a three-cornered conversation. When he learned that I was with Dunlop Mr. Kahle was delighted and at once told me that he was the Dunlop agent in Bauka. I told him I wanted to send a cable to the Dunlop Company in London to let them know where we had got to. He got a call through to Batavia the following morning and I was able to speak to Martin, the Dunlop manager there. Martin promised to send a call to London and to let me know the position if I could call him up again. Mr. Kahle got this second call for me.

"I stayed with the Kahle family for ten days and they were kindness itself. We were stranded; there was no shipping; we could not move.

"At last we were given the chance of going to Java on a tiny Dutch steamer and on 1st March we set off. Mr. and Mrs. Kahle insisted on getting my breakfast at 4 a.m. and although they were staying behind they were genuinely delighted that I had the opportunity of leaving.

"We never reached our destination in Java. Just before we got to the Sunda Strait, which separates Java and Sumatra, the Captain of our ship received instructions to proceed to Colombo, and at once turned about. The seas were infested with Japanese craft and the skies full of their planes. Our speed of four knots made us a sitting target, but we never saw a plane or ship of any kind until we reached Ceylon.

"Immediately we landed I went to the Dunlop office and there received good news of my wife. She had reached Colombo some weeks before and the Dunlop District Manager had helped her with food, money and clothes. He and his wife were most kind to us and I and one other of our party stayed with them for several days to rest and recuperate. I then started my journey to Bombay where I found my wife had been cared for by the Dunlop District Manager and had obtained money and everything else she needed. He and his wife had been more than kind and I realized more fully than ever before what it means to be a member of the Dunlop staff in times of trouble such as these."

The good fortune of Mr. Hawkins in eventually escaping from the Japanese was not shared by many others. Amongst important Dunlop officials who fell into enemy hands and endured years of torment and brutality in concentration camps was Dr. William B. Haines, a soil expert employed by Dunlop Malayan Estates Ltd. He was one of the

scientists who did early research work on the atom bomb. The thrill which he describes when he learned that his eventual release was due to the atom bomb dropped on Japan is quite understandable.

Dr. Haines's experiences, as told in his own words, are as follows:

"My retreat from Malaya began when, after the very grim Christmas of 1941, I took my wife down to Singapore to see her off for Sydney. Disaster was in the air, but that was nothing to the 'phoneyness' of going back to Malacca alone to take it on the chin when every dictate of common sense and usefulness pointed to leaving with her. A few days of open house followed for up-country people on their way through—tea and biscuits and cushions on the floor at all hours. Then came my own turn to retreat; a car filled with groceries and bedding and a boy who elected to stick by me. He, by the way, most staunchly did his stuff for all and sundry who made demands, right up to the moment of our parting on the dock.

"Singapore at first seemed strangely normal. I had expected to find Europeans so crowded they might be living in their cars, but accommodation went smoothly. I took a job censoring (vacated by the women) and it will not be breaking my oath if I record that I was much impressed to observe that man's high regard for his partner does not fade with the marriage ceremony.

"The real excitement began with the last week. As the Japs landed on the Island I got at one and the same time a cable announcing my wife's safe arrival in Sydney and my Dunlop cheque for leave-pay. The first indicated a troubled journey, since it had taken six weeks, but I have not got that story, as she did not live to rejoin me. The second was a reminder that a few weeks more would have seen me away safe in Australia, for in the normal course of events a plane berth had long been fixed for me for March 16th.

"Guns arrived in our garden in Tanglin, early in the last week. It is curious that, although I have the clearest visual memories of everything, I have only uncertain memories of what it all sounded like. On Wednesday the house was in the line of fire and I only got in during a lull to remove my last belongings. We crowded into a room at the Raffles. The drains were running whisky and the Australians out of the line were clustered around the waterfront. The *Empress of Asia* was lying with steam up across the water and men of her crew were wandering the streets barefoot. Everywhere were parked cars without owners. I had not been able to mess with the Dunlop staff, but had thrown in my lot with a friend from Kuala Lumpur.

"On Thursday came our reprieve from the ban on men leaving. Work had ceased and I had retired to a quiet corner of the Raffles, after a lunch with my friend out of our own tins, when a stranger came up to say that the Chief Justice had telephoned the information that he would issue passes on application. I knew that to remain would be safer, but the prospect of taking into internment a regret that I had not tried

my chance to get away was more than I could face. Within an hour I was on the Gian Bee. On coming out of the Court I found an Australian deserter was trying to steal my car. He could have had it ten minutes later, although the Japs were only walking distance away in every direction.

"The ship left that night with huge oil fires burning all round the horizon. Unfortunately, we were headed for Batavia when the route to Colombo would have given us a better chance. Friday the 13th was a day of slow progress, with volunteer stokers down below and constant bombing overhead. Five attacks by flights of up to nine Japanese aeroplanes resulted in nothing more than two near misses. Later events were to show that two of the lifeboats had been holed by splinters.

"The evening brought the crisis when the Jap fleet steamed up. Then occurred one of those tragic mishaps of war's blind struggle. After circling us many times with guns trained, the Japs apparently decided to take us as a prize and a small boat was let down and began to come across to us. Then out of the evening sky a lone Allied plane made a momentary strafe. Whether they thought we were a decoy we never knew, but the boat was recalled after some delay and our order was to abandon ship. This was done in an orderly way, the boats having accommodation only for women and children. When these were away it was *sauve qui peut* and my friend and I jumped into the water—whence all the sharks had fled because of the bombing—to be soon hauled aboard one of the lifeboats.

"As the way of escape narrowed down to the eye of a needle it seemed to become instinctive to abandon belongings, and I left my shoes and satchel on the ship's deck when I jumped into the sea. This was a greatly regretted mistake, for they could have been saved with me. The valuables would have kept me in funds during internment and the papers would have saved me from endless legalities in re-establishing my claims to shares and other property.

"The Japs made no attempt to save anyone and late that night we saw searchlights and guns open up for a moment and the ship went down in flames. There were wounded on board and at least one wife who refused to leave her wounded husband. Two of the four boats must have been lost by waterlogging: the other two saved about 100 people.

"We made towards Sumatra and with a little better luck would have reached Jambi and got through. However, we made too southerly a course and reached Banka Island after 36 hours. We were then too crowded to risk a further voyage. I landed with nothing but my shirt (the oldest one in my wardrobe which yet bought me an egg on my release five and a half years later), shorts, and an Oyster wrist-watch.

"The Japs gave us nothing but our meagre rations and from then on I lived on what I could improvise from refuse heaps. The fierce reception given the Australian nurses as they came ashore from a sister ship, the *Vyner Brooke*, is a matter of history. We escaped this by landing in a more

remote part of the bay where it took some ten days for the Japs to make contact. Other ships were taken into Muntok without loss of life.

"The first two years were merely extremely miserable though with few deaths after the first few weeks. Then we were moved back from Muntok to Palembang. There was malaria here, by which nearly everyone got infected and the amount of quinine allowed was probably not one-twentieth of that required, and very intermittent at that. The meagre rations were severely cut from April 1944, and graft and maldistribution of food within the camp grew worse and worse. A large proportion of the "Dutch" were, of course, of mixed blood. The death roll went up to five per day in November in a camp of some 800 souls. It was possible to estimate one's prospects from one's weight and the simple fact that at least 2 ounces per day was being lost from the absence of protein food alone.

"In February 1945 we were moved back to Sumatra under shocking conditions, but the new camp was a little better. The figures for male British, as far as I can remember, were 167 at the beginning, of whom 110 died. The most tragic death to me was that of Longland, a senior Dunlop manager, a dear fellow, who went through it all very patiently, but fell sick a few days before the unexpected end of the war. As none of us had any resistance left by then, he died the very day of our release.

"The system of privilege and the inequalities that had gradually developed within the camp were quite shocking before the end.

"As a physicist who had done some early research on the atom, it was a special thrill to me to hear that the atomic bomb had brought our release. This news was brought by three lone parachuters all the way from Colombo, who dropped down to face the whole Japanese Army. Stores were flown over from Cocos Island and no praise could be too high for the arrangements made by R.A.P.W.I. all along the line of our homecoming. One of the best parts of our warm welcome was to learn of Dunlop generosity and humanity in their handling of the affair."

Through many accounts of the war experiences of Dunlop representatives in all parts of the world one strain keeps recurring: the loyalty of everyone even remotely connected with the organization to everyone else in it. This loyalty saved many lives, reduced the distress of mind of those who had become separated from their loved ones, and made situations endurable which would otherwise have been too much for human fortitude.

Grim enough, but not quite so grim as the foregoing, were the experiences of Mr. F. R. Gibbings, Dunlop representative in Shanghai and one of the most widely known men in the Far East. Early in 1938 he had visited Chungking to discuss transport problems with the Chinese Central Government, and his pro-China attitude and the fact that he had countless friends amongst people of that race was well known to the Japanese invaders.

On Mr. Gibbings's advice, steps were taken at the very beginning

of the war to dispose of Dunlop stocks and other saleable assets in China with a view to remitting the proceeds to England while this was still possible. As a result, out of assets worth something like £220,000 sterling, all but about £10,000 worth were realized and the proceeds received in London.

Some of the methods used were most ingenious. For example, the Company owned an office building in Tientsin, which it was impossible to sell. A mortgage was raised on this for about two-thirds of the market value at 8d. to the Chinese dollar and the money sent home. Later on, when the dollar had fallen to 2d., as a result of Japanese activities, the mortgage was paid off. Afterwards the property was sold and the purchase price sent home. When war broke out with Japan the Japanese invaders seized all the godowns and warehouses owned by British subjects and sealed them up. They also blocked all bank balances, leaving each firm with only a few thousand dollars with which to liquidate their businesses.

This meant that many British firms had to dismiss their well-tried Chinese staffs without compensation. When the Dunlop godown was being inspected by the Japanese it was noticed that one of the Japanese officers took a great interest in the small remaining stock of Dunlop "65" golf balls. It was discovered that he, like many of his countrymen, was an enthusiastic golfer. By means more familiar in the Orient than in Britain, some of the balls were passed into his possession; and the Dunlop godown was left unsealed.

Although a large part of the contents consisted of damaged cargoes, old packing cases and the like, Mr. Gibbings managed by carefully husbanding and gradually disposing of the stock and rubbish not only to pay off those of the Chinese staff for whom work could not be found with the full amounts standing to their credit in the Company's Superannuation Fund, and to retain the few essential men, but also to maintain the British staff in comparative comfort until they were all interned a few months later.

Mr. Gibbings himself had some uncomfortable experiences. One day there appeared in the Shanghai newspapers a paragraph, copied from the Japanese Press, describing the Dunlop organization as the greatest British spy network in the Far East. Mr. Gibbings fully expected that he would immediately be arrested and taken to Bridge House, a concentration camp where the most suspected persons were interned and which was notorious for the ill-treatment of prisoners. Next morning, while he was in his bath, his Chinese servant knocked at the door in great agitation, saying that two Japanese soldiers wanted to see him. Mr. Gibbings dressed in considerable perturbation and went to the door, only to find that the men wanted to sell him the Japanese paper printed in English in Osaka for propaganda purposes. Mr. Gibbings hastily enrolled himself as a subscriber for twelve months, paid up in advance, and went back to breakfast.

Two other members of the organization who were in Java when the

Japanese entered the war and who were later captured and spent long and hard years in prison camps were Mr. L. R. Martin (referred to in Mr. Hawkins's account) and Mr. L. E. Nuttall, representative of the Company in Batavia. Both of these were members of the Batavia Volunteer Unit, a somewhat anomalous body not at that time recognized by the British Army. The members were provided with Dutch uniforms and trained by Dutch officers, but incorporation into the Dutch Army would have involved an oath of allegiance to the Queen of Holland and other difficulties. When the invasion took place they were attached to the British forces for liaison work.

On the capitulation of the Dutch, the Japs acted with their usual speed and brutality. Messrs. Martin and Nuttall were in Bandoeng. At nearly midnight of 13th April, 1942, there was a loud knocking at their door, followed by the entrance of a Japanese soldier with fixed bayonet and a Jap N.C.O. with a Dutch policeman for guide. They were given ten minutes to dress and pack one article of luggage. When they reached the road they found a lorry waiting already containing Messrs. Harper and Irens, of Harrisons & Crosfield, who were handcuffed together, a situation in which Mr. Martin and Mr. Nuttall soon found themselves.

They were taken to a prison camp about ten kilometres from Bandoeng, where they were fated to remain until February 1944. The cells in which they were imprisoned were nine by five feet in area. This seemed pretty crowded, but by 1945 the Japs were putting three and sometimes four men in the single cells. For the next seven months they were locked in their cells for 23 hours a day, being allowed an hour for exercise and a shower.

The most humiliating part of their experience was that about 300 of the native criminals, mostly murderers, for whom the prison had been built, were still there and were given supervision of the white internees. In the middle of November 1942, the prisoners were handed over to the Japanese civil authorities and conditions somewhat improved, but during the military régime there had been much beating and torturing and several people lost their reason.

In January 1944, another change was made and they were taken to a former Dutch Army camp at Tjimahi, and handed back to the care of the Japanese Army. From then onwards conditions deteriorated at an appalling rate. Epidemics of dysentery and other diseases took many lives and tropical ulcers were evident on all sides. The brutalities and bestialities perpetrated by the Japanese army in this camp are too nauseating for description here, and anyway have long since been officially recorded and proved.

In early October 1944, the Japs selected a number of prisoners whom they chose to consider as especially dangerous for removal to another camp, and Mr. Martin found himself one of the group. The position of the hospital patients in this camp was so desperate that the

doctors offered a reward of 300 grams of sweet potato for snakes and rats from which soup could be made. One of the rats caused a death by bubonic plague.

A certain amount of news was received by the prisoners by means of radio sets which had been slowly and painfully assembled and operated under the threat of death. The prison camps also managed to communicate with each other by ingenious means. In one case a Japanese commander had jurisdiction over two camps and it was his custom to ride his bicycle from one to the other. He became the medium for messages which were concealed in his removable hand grips and retrieved by a friendly native at each end.

When the war in the Pacific ended so suddenly in August 1945, the people in the camps were unable to believe it, because wild rumours of all kinds had often circulated through Java, only to be disproved later on. However, on September 28th, Mr. Martin and the others were moved by train to Batavia and were back in a few days in the civilization and freedom of Singapore on their way home to Britain. It had been three and a half years of unrelieved, atrocious misery for all of them.

Sumatra, Burma, Siam

The adventures of J. A. Beck, No. 1 Dunlop salesman in Batavia, form yet another episode in the unending saga of cheerfulness under intolerable hardships. When war was declared on Japan by the Dutch Government on 8th December, 1941, following the Japanese attack on Pearl Harbour, Mr. Beck was living with his wife and two children at Medan, in Sumatra, where all Allied Europeans were mobilized within twenty-four hours. After a few weeks Japanese planes began to come over when "we tried to drive them away with double-coupled Lewis guns and Fiat machine-guns, but with practically no result." After a variety of special missions to Padang and other danger centres, he was dispatched to "a brand-new, beautiful airfield, near Siantar. During the night it was terribly cold, and we had no blankets, no coats, no special underwear to keep ourselves comfortable—once I was on guard duty during ninety-eight hours at a stretch without sleep or rest.

"On 12th March, 1942, at nine a.m. Japanese bombers came roaring over, and soon news was received that 20,000 Japanese troops had been landed about thirty miles away, and 25,000 men farther away. We could not help laughing when we heard these figures, as the whole army of Sumatra, including regulars and irregulars, did not amount to 10,000 men who, moreover, were not equipped for modern warfare." So Mr. Beck and his friends were forced to leave their families and to march inland. "The road had been blown up in several places and two tunnels through which the road led had been destroyed, but this did not seem to worry the Japs in the least. They simply took their bicycles on their shoulders and climbed over the mountains steadily advancing towards us. Although their casualties were many we could not stop

them. There were too many of them, they came upon us like ants, whereas we had only 150 to 200 men to fight them. . . ." Soon the little band were in full retreat. After long and continuous marching, and feeding upon what they could find, some four or five of the 180 left approached their commander, complaining of this long retreat and demanding that they should "fight it out with the Japs or surrender." They were informed that at four a.m. on 28th March they would make a counter-offensive, but when the morning came they were awakened, not for the supposed attack, but for surrender.

On 29th March they "got their first taste of life as prisoners of war under the Japs. When the surrender took place we were promised safety of life, complete possession of our personal belongings and valuables and the colonel hoped we would soon be home again and would take up our normal civil duties in a few days' time. This always sounded to me as a very good 1st April joke, and the more I saw of Medan, and the longer I saw the Japs, the more this joke seemed to come true. It took exactly four years before I saw my wife and children again.

"We were lined up, and then brought to Japanese Headquarters, where we were allowed to sit down on the pavement and received a banana per man, our food for that day."

The Japanese colonel who inspected them was very much surprised to see that "our whole unit of North and Middle Sumatra did not amount to over 5,000 men." They were warned that everyone who tried to escape would be shot, and "instructed to salute or to bow to each and every Jap, as by their grace only we were still alive." They learned meanwhile that their wives and children had been interned on 15th April under transport conditions of inhuman barbarity.

They were marched to the docks and "with the assistance of rifle butts and kicks from military shoes" were sent below deck on an old American ship, and forced into a space of half a square metre per man. "There was no question of lying down and most of the time we had either to stand or to sit crumpled up with our chins under our knees." Within two or three days "dysentery broke out on board. We had no medicine whatever, everything being confiscated by the Japs, and we soon had our first losses."

After landing in Burma they knew what slavery meant: "We were beaten with sticks and kicked all around if only one of us stretched his back for a second. We had nothing to eat or drink during the day, but when work was finished about midnight we started to prepare some food of our own." It is gratifying to learn that, during their march from Tway to Tavoy, "we shall never be able to forget the kindness and the hospitality of the Burmese people. They overloaded us with fruits, meals, cheroots, etc. . . ." nor were the Japanese able to prevent them. Dysentery increased with the lack of sufficient food: "with 300 men we received a daily ration of rice and eighteen egg plants."

Road-repairing proved comparatively easy work. "Our Japanese

guards were not much interested and went off for a sleep. When an officer came we had to wake them up." But the building of the Burma-Thailand Railway was a tragically different matter. They had marched —serious dysentery patients included—barefoot along the railroad track, "making forced steps from one sleeper to another or walking over the splintered rocks between." They were lined up before Colonel Nagatomo, Commander-in-Chief of all Prisoners of War in Burma. He "told us what rats, dogs, rebels and pirates we were . . . that now had come the time to show our gratitude toward the Japanese Imperium for the goodness they bestowed on us, that we should gladly undergo the miseries and the consequences of the hard and bitter life that lay ahead of us. . . . A railroad would come no matter at what expense of human lives. We were given a year to finish our part of the railroad and he would see that it was finished within a year"—at any cost.

The inhuman toil began in August 1942. Dysentery attacked most of the men, often for long periods. For bridge building they had to work "in two shifts of eight hours each . . . up to our necks in water." Work was forced on day and night. Often their only shelter was "a few deserted and ramshackle huts without roofs or anything." Prisoners captured attempting to escape were shot. At Christmas the Japanese "to show how friendly they felt towards us . . . would give us a Christmas surprise. A truck, loaded with baskets full of oranges, entered camp. Some of our boys were ordered to unload it, and to bring the oranges to our kitchen . . . when, crumpled between the baskets and the cabin of the truck, they found the bodies of recaptured fugitives, tied hand and foot, and one of them seriously injured. The Japs thought this a real good joke, and laughed their heads off. . . . The prisoners were shot on 28th December."

By mid '43, "people were suffering from dysentery, malaria, jungle-fever, beri-beri, under-nourishment, skin diseases, tropical wounds, etc., etc. We had no clothing whatever, no bandages for the wounded, food was too poor for the hard slavery, people felt ill, miserable and deadly tired. Still I must say that in general we did not feel downhearted. Whenever we had a day's rest some sort of a stage-show was performed, songs were heard in the late hours of the night and nobody lost his good humour."

All this though "when the doctors could not supply the Jap with the number of workers wanted, the so-called 'hospital' or the barracks themselves were visited by the Japanese guard, armed with bamboo sticks, and with the aid of these and of their rifles, fists and shoes everybody was driven to work again whether he could stand on his feet or not."

"Amputations were carried out with ordinary wood saws, operations were performed with old razor-blades and pen-knives. We had no narcotics, nor disinfectants, and they were carried out only to save a man's life. . . . In the early hours of 17th October, 1943, we heard the click-click of hammers on the other side of the line. We were approaching the people who were working from Bangkok to meet us." Even then "we were not to have any communication with our comrades of Thailand.

When only one other length of twelve metres of rail had to be laid between Burma and Thailand we were withdrawn, after 40 hours of continuous slavery with practically no rest, food or drink, for two miles and allowed to sleep in the ditches alongside the railroad.

The 153 kilometres was finished, at a cost of over 18,000 lives of Allied prisoners of war and over 67,000 natives. "Our rations were then cut down to dry rice and chili. Our hope of return to Sumatra vanished when we learnt that a new railway track had to be built to improve the one just finished." By the end of March 1944 they were in Siam where "after almost two years we saw women again, nice Siamese girls and modern, with bobbed hair and their colourful dresses. . . ."

By mid April they were in Bangkok, and "saw Europeans again, Europeans living in liberty, men, women and children . . .. I cannot say that we felt very happy when marching through Phom-Pheng, only partly dressed in a few rags, unshaven and filthy. In Saigon it did not take long to build up a well-organized communication with the French. Money, medicine, news were coming in daily under the very nose of the Jap. At last we had a secret radio set buried in the kitchen under an iron fire plate." For months they worked at loading and unloading of ammunition. The first air raid on Saigon took place on 6th May, 1944; but on 12th January, 1945, "Saigon was really dealt with by Allied dive-bombers. By the time the fight was over the Japs had lost 67 ships and 101 planes—all sunk or destroyed." By February 1945, at a new airfield in Phu-mi, fifty miles from Saigon, they were "working in an open field from morning to night without the least shade, with heaps of grass, dry leaves, branches of trees burning, suffering from the sun and heat caused by the fires; we sometimes did not even get a drop of water to drink although buckets, full, were standing within 60 yards of us."

"In the night of 12th-13th August, we heard on our radio that Japan had surrendered. We could not believe it, and no one was filled with any emotion or gaiety." And even when "arriving at Saigon, with prisoners of war on the docks, dressed in white shirts and trousers, one of them even with a necktie, we were told that things were up, I cannot say we were very enthusiastic. Strangely enough, I did not care anything to go out of the camp."

In Saigon, the Annamites, armed to the teeth, and led by Japanese officers, were shooting at the French "with 'we prefer death to slavery' and more of such nonsense."

Among Mr. Beck's other stories of light-hearted courage is that of the Australian who, still in possession of a good pair of shoes, had to have one of his legs amputated. A few hours after the operation he bent over his bedside and picked up one of his shoes, exclaiming: "Who wants to buy a left shoe? I don't need it any more."

One rejoices to learn finally that on 5th March, 1946, this humorous and plucky prisoner got ten days' leave to go to Medan, exactly four years since he had last seen his wife and children.

CHAPTER XVII

THE FUTURE

WHAT sort of future awaits this giant concern? Before, and during the war most would have predicted at least an immediate industrial boom which, controlled by the world's sad experience of after-war prosperity, would not have been allowed to end in a slump. But what is the world feeling now, after more than a year's complete immunity from ruin by land, from the air and under the sea? Physical relief and reassurance have been tempered by the unchaining of the atom. Politically there seems but small reason for enthusiasm; while the economic horizon, chequered by suspicions abroad and strikes at home, is gravely overcast.

These are immediate impressions of the present atmosphere. How far is that likely to affect the prospects of Dunlop? I will attempt a balance-sheet of probabilities, bearing always in mind that, peace or war, boom or slump, the world will still need transport—and weather protection.

MATERIALS—DUNLOP RUBBER PLANTATIONS

Throughout the war, no question evoked more speculation throughout the Dunlop organization than the fate of the Company's properties in Malaya, the largest single unit of acreage under one ownership in the British Empire. During the three and a half years of Japanese occupation almost no reliable news came through as to the state of the plantations or the fate of the people who had the misfortune to fall into the hands of the cruel and ferocious barbarian.

When British arms freed Malaya, at the beginning of September 1945, information began to trickle out. On the whole, fuller details showed the position to be much more encouraging than had been thought probable. Of the Organization's European members, eight escaped when the Japanese occupied the country; a few had been recalled to the services and many others had volunteered and were fighting in Malaya. Of these, three were killed in action, the remainder, together with 40 non-combatants, fell into enemy hands. Seven of these died in captivity. The others, although their experiences were harsh and unpleasant enough, even in retrospect, were eventually saved; many have been and all may hope to be restored to reasonable health.

The rubber production capacity of Malaya was far more than the Japanese were able to utilize; it was therefore not surprising to find that the greater part of the estates had been utterly neglected. Less than one per cent of the rubber trees had been cut for fuel, for timber requirements, and to make room for food crops. But neglect of a tropical plantation has a disastrous effect on agriculture because of the rapidity with which the jungle invades cultivated areas, and the quick, deadly over-

running of pernicious weeds. These effects are worse where the shade of the tree is deficient and the direct rays of the sun on the soil foster noxious growths. In this respect the Dunlop properties were very fortunate. For years the Company had been experimenting with "bud-grafting" with a view to increasing yields. One-third of the total area consists of young "budded" rubber trees, densely leaved, whilst almost the whole of the rest had been heavily manured for years before the war, to the great enrichment of the foliage. On Dunlop estates, therefore, the jungle growth and weeds were found to be largely confined to young and immature plantations (where the yield of latex would have been small anyhow) and will not prove an insuperable difficulty.

Apart from damage done under the Japanese "scorched earth" policy, and very extensive looting of all transportable articles, it was found that both residential and factory buildings had survived reasonably well and were at least capable of repair. All furniture and fixtures, including even door hinges, had been removed. Plant and machinery were generally in fair condition, but all aluminium and nearly all electrical equipment, belting and machine tools had vanished. All transport had disappeared, and as mechanical transport is vital to the efficient operation of the estates, this was a serious handicap in their rehabilitation.

Of the native labour force of about 15,000, hardly 6,000 were found on or near the estates when the first investigators arrived. The Japanese had transported many thousands to Siam for work on the Bangkok-Rangoon railway, and as military reports have shown, a high proportion of this force, both native and European, were ruthlessly worked to death. It seems useless to hope that any but a small minority of the native labourers thus transported will ever be seen again, and the recruitment of the new labour force entails yet another formidable operation.

Yet within four months of the war's end, despite almost incredible difficulties in the way of transport and of supplying food, Dunlop already had a nucleus staff at work in Malaya, busy rebuilding the Organization, providing medical requirements for what remained of the labour force, distributing food, and giving light work to those whose physical condition permitted any activity. Meanwhile arrangements had been made for sending out the necessary field and factory equipment as soon as labour should be sufficient in numbers and condition to resume normal work. All this was only possible as a result of very complete and detailed planning which was done in London before the re-occupation of Malaya.

The position at the end of 1946, however, is likely to be even more encouraging for it is fairly certain that by the end of the year the production of the Dunlop Malayan estates will be almost back to pre-war figures.

No man can yet say how much time must elapse before the plantation rubber industry generally will recover. The transitional period may last for three years or even longer. In a situation where 90 per cent of one of

the world's most vital agricultural products has been almost completely suspended for three and a half years, there are too many imponderables and unpredictables involved to permit of prophecy. But whatever the interval before full resumption, the future of natural plantation rubber seems reasonably secure.

Natural and Synthetic Rubber

In 1940 the world produced 1,390,000 tons of natural rubber, of which 1,100,000 tons were consumed by Allies and neutrals. In 1941, under the spur of the war raging in Europe, production rose to about 1,500,000 tons. Of this, all but 175,000 tons came from areas afterwards overrun by the Japanese. This 175,000 tons was the sole nucleus of supplies of raw rubber against Allied requirements of more than 1,000,000 tons. The position was saved mainly by American synthetic, but this, invaluable though it was, would have been of little use without something more than 200,000 tons of natural rubber per year for mixing with the synthetic. By a great effort throughout the free world, the annual output of natural rubber had been raised by 1944, from 175,000 to 280,000 tons. Of this increase only 50,000 tons came from non-occupied plantations, which in 1940 had produced 107,000 tons. By tremendous exertions, production of wild rubber from Africa and South America was raised from 33,000 to 88,000 tons. Of these three sources it seems probable that the plantation rubber area outside that held by the Japanese will be maintained, but that wild rubber will fall to its pre-war level. The great bulk of the world's natural rubber supplies in the future must come from the Far East; even the best wild rubber will, for many reasons, never again be able to compete with rubber from the plantations.

"Autarkic" enthusiasts of the United States pressed for large plantation rubber development in South America; for security reasons, and to avoid being again cut off from natural rubber supplies as they were so quickly after the Japanese attack on Pearl Harbour. This venture would hardly seem probable for five reasons:

(*a*) Rubber supplies may exceed world requirements after a few years, and there are economic and political reasons why the United States would not wish to impoverish four extensive territories. The trade agreements connected with Bretton Woods negotiations have made this clear.

(*b*) Vast new rubber plantations would cut across the American programme of synthetic rubber development, and might involve the loss of an invested capital of £250,000,000.

(*c*) They would necessitate the development of a rubber tree which would be proof against the deadly leaf disease of South America. This may be possible, but Ford experience on the Amazon seems to show that it has not yet been achieved.

(*d*) South and Central American labour is less efficient, more costly, and less amenable to training than Eastern labour.

(*e*) Nature, although it did not create the rubber tree indigenous to the Far East, did nevertheless, create there conditions for its development which are incomparably better than in any other place in the world.

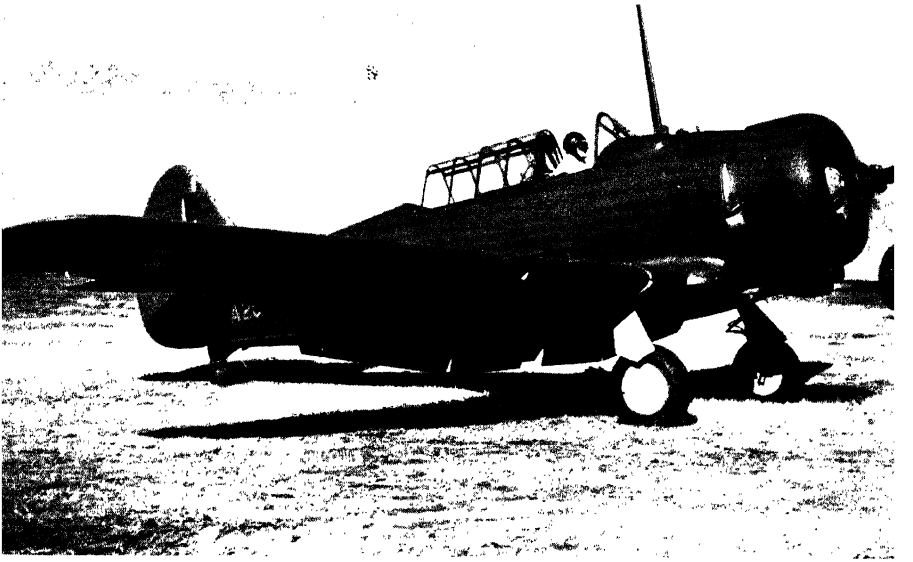
During the transition period supplies of synthetic rubber will be essential to fill the gap, as some time must elapse before natural rubber can be produced in satisfactory quantities. But in years to come the future of each product must be determined by intrinsic value and open competition. It is at present futile to dogmatize about their relative eventual positions.

Suffice it that the tide has turned: the Japanese assault has been repulsed although the breach is not yet repaired, and one of the richest and most heavily populated parts of the world is on the path of reconstruction. In this work Dunlop is by force of circumstances a leader, and in many ways the chief leader, in bringing rehabilitation and renewed happiness and prosperity to the Far East. The Company's vast plantations and unwearying research work benefit the whole industry and through it the Empire. The inherent necessities of the rubber industry call for large units. The preparation of latex for export under conditions where it can compete economically with rival products postulates technical and managerial control which are only possible in large factories.

I have stated that the relative position of natural and synthetic rubbers must be decided in the future by intrinsic value and open competition. Even before the war certain synthetic rubbers having special properties, notably oil resistance, were coming into prominence for special uses. During the war period considerable progress was made in the production of synthetic, often on a large scale, suitable for general use.

The production of a general purpose synthetic, G.R-S., good enough to carry the tranport of the United Nations to victory, was a fine achievement. At the same time, individual synthetics, whilst possessing some superiority over natural in certain respects, fell short in others. While work on improving synthetic is going forward, the Company are studying the production of natural rubber possessing improved or special properties. In this direction, a long term research study has begun on breeding from trees yielding rubber of the desired characteristics or qualities, on the modification of natural latex for the making of softer rubbers which, since they are easier to work in the factory, offer more uniform and higher quality products; and on treating the latex in other ways to produce rubber with better mechanical qualities, better ageing properties, faster vulcanization and improved resistance to oil.

Until recently, the principal synthetic rubbers were (like natural) hydrocarbons; that is, they contained carbon and hydrogen only. Very recently synthetic has been produced in which the basic element instead of carbon is the closely allied silicon, an element in the form of silica and silicates extremely widespread in nature, forming about 26 per cent of the earth's surface crust and thus representing the second most



Above: An Australian plane with tyres by Dunlop.

Below: Waterproof patrol boot manufactured by Dunlop Australia. This left a track similar to that of Jap army sandshoes, and misled them into believing that prints made by Allied patrols were those of their own men. (See Chapter XV.)

Above: The Native football team from the Durban factory.
(See Chapter XV.)
Below: The canteen at Durban.

abundant element, second only to oxygen. At present silicon rubbers are inferior in several respects both to natural and to many of the synthetics based on carbon, but they are able to stand much higher temperatures without decomposition. Experiment will doubtless eliminate their present less satisfactory features.

The important new technique developed to enable rubber latex to be used directly for the production of rubber articles will soon be extended to similar use of the many synthetic rubber latices and the numerous new plastics.

No way has yet been discovered of completely removing the sulphur from "used" or vulcanized rubber, so as to leave a rubber hydrocarbon entirely suitable for re-use. But more is constantly being discovered about the chemistry of vulcanization so that in a few years a problem which has long baffled rubber chemists may well be solved.

Much work has already been done on the bonding of rubber to other materials, but improved and simplified methods and better adhesives are still needed. Rubber and its analogues can be converted by chemical means into new substances with novel and interesting properties.

Cotton, Rayon and Nylon

The textile element in tyres and many other forms of rubber products is almost as important as the rubber content. The rapid expansion in the use of rayon for tyre manufacture is perhaps the outstanding advance in tyre textiles arising from the war. Rayon had previously been little used for this purpose either here or in America, but enough to indicate its value, particularly under service conditions. The war has seen rayon firmly established as a giant tyre cord. This is largely because it deteriorates less under the action of heat than cotton, and so where temperatures are high—owing to high speeds or heavy loads—rayon shows to advantage. Moreover, rayon permits the production of stronger tyres of equal weight to cotton tyres, or alternatively, lighter tyres of equal strength for aeroplanes, where the importance of light weight equipment is obvious.

The prospects of rayon for car tyres are not so clear. Cotton still provides excellent service for most purposes, so that the special properties of rayon are not required so much as in giant and aeroplane tyres. Nevertheless, it is probable that in the peacetime motoring world, particularly for high speed cars, the advantages of a rayon cover may outweigh the higher price. Meanwhile work on cotton cord is not being neglected; advances in cord manufacture are being made which will tend to narrow the gap between the two materials, and a large proportion of tyres, particularly motor-car tyres, will continue to be made with cotton casings for some years to come. But the Dunlop Board attaches such importance to rayon that they are building a new factory at St. Helens solely for the purpose of doubling and processing rayon yarn.

Nylon is another artificial fibre which has during the war been developed as a tyre casing material, particularly for aeroplanes. It surpasses in strength and elasticity any other textile fibre, and therefore has great possibilities where lightness is an essential. But nylon is at present much more costly than rayon and cotton, and as it will be scarce for some time, it is unlikely to be used appreciably in the near future.

New Synthetic Materials

War conditions necessitated substitutes for natural rubber, and a wide variety of new synthetic materials was developed to meet the emergency. Some of them have advantageous properties of their own and are not only capable of replacing rubber but open up new fields. The Company has kept well abreast of these developments and its future manufacturing programme will include products employing the new materials. Considerable research and investigation have been carried out to ensure that the new products are of the highest quality and that the machines and processes are the best and most efficient.

Novel applications of these new synthetic materials in the fields of garments, curtains, articles for personal wear and adornment, and other things are promised. To take full advantage of their possibilities, attractive and suitable designing is called for, a matter to which special attention is being directed.

The new materials have been found to be useful in other fields. For instance, some of them are valuable adhesives and they are being included in the plans the Company is making for specializing in compositions of this nature. Upholstery also holds a big potential for the new synthetics. They can be coated on to fabrics to give excellent leathercloths, and some of them can be converted into threads from which upholstery fabrics can be woven.

Developments such as these are for the immediate future, but longer term policies have not been overlooked. Naturally, the time is not ripe to divulge them in detail, but it can be said that one important project lies along the lines of discovering or synthesising new basic materials or modifying existing materials so as to give them special properties.

Latex

The Dunlop Co. has always been in the forefront with developments in the use of rubber latex. The "Dunlopillo" and "Lastex" processes and products are now known and used the world over, and the Company's latex-dipped goods form a substantial part of its many products. War-time conditions restricted developments in these fields very considerably, but also created new opportunities by making available new dispersions of synthetic rubbers and polymers. While it is true that for "Dunlopillo" and "Lastex" goods no satisfactory substitute for natural rubber latex has yet been discovered, the possibilities along this line are not to be overlooked and are under continual study.

Research Methods and Technique

All this use of new and adaptation of old materials involves intensive and highly skilled research. Recent progress in physics has perfected and applied new instruments which have been summoned from academic seclusion to become powerful new tools for the investigation of the structure of rubber and allied materials. Among these new instruments the *electron microscope*, the *infra-red spectrometer* and the *X-ray diffraction camera* are the most widely used. Dunlop's research laboratory has made plans to install the equipment in its new premises, has approached Universities and institutions already possessing the instruments, and has initiated studies of rubber and G.R-S. structure; as well as of that problem of paramount importance to the tyre trade—carbon-black. The complicated chemistry of vulcanization with accelerators is being studied by means of the infra-red spectrometer.

Radiography

To maintain and enhance quality, the use of *radiography*, i.e., X-ray shadow pictures, is now common in many industries. In the Rubber Industry the nature of the materials and structure usually makes the technique difficult; nevertheless much valuable information about the internal structure of tyres, tubes and other rubber products can be obtained. Dunlop has had the most up-to-date X-ray plant in operation since the mid-war period, and this has proved the great value of such non-destructive testing.

Heating by Short Wave

High frequency heating is a new field for improvement in production. The ability to heat the centre of non-conducting rubber or cotton opens up entirely new methods of dealing with thermal problems. Improved and more rapid vulcanization has been achieved for thick rubber blocks, damp cotton and rayon can be dried in bulky packages, and the glue in a laminated structure, such as the Dunlop tennis racket, can be heated to setting point in a few minutes without appreciable heating of the adjacent wood.

Static Electricity Problems

Static electricity problems in factory, hospital and bus provide a good example of original processes emanating from research. One of the difficulties incidental to the use of G.R-S. was the enforced introduction of dangerous varnishing methods using inflammable solvents. Most rubber companies found obstacles in this process, owing to the fire risks from static sparks as the fabric rolls through the machine. An intensive study of the origin of the powerful charges (often as high as 250,000 volts) led to the invention of a remarkably sensitive and accurate instrument which measured the static charge at several yards distance from the source.

Once the charge was measurable, the development of a simple device to "kill" the static followed in due course, and this previously perilous varnishing operation can now be considered safe. The experience acquired here was used in helping the hospital authorities in their battle against static in the operating theatre, where the inflammability of the anaesthetic makes every precaution necessary. The correct use of conducting rubber bedding, shoes and floors has been determined, with the Dunlop electrometer indicating the presence of static long before it reaches a level sufficient to cause any risk of fire. For the prevention of static shock on buses, the measurement of the voltage and leakage has given the essential data which enables the proper corrective measures to be taken.

New Research and Development Laboratories

With so many new or expanding technical developments in the field of rubber and allied materials before it, the Company finds it necessary greatly to extend its research activities. They are therefore transferring them to two existing modern buildings on a site adjacent to Fort Dunlop. The larger, of two storeys with total floor area of about 130,000 square feet, will house most of the departments concerned with research and the discovery and development of new products. The smaller, which will be enlarged to an area of about 15,000 square feet, will be used for experimental and pilot plant installations. The research will cover investigations on behalf of the whole Dunlop group and will be arranged in four main divisions, Chemical, Physical, Compounding and Textile.

Products

Now for the products which Dunlop is planning to make with the materials and technique, the scope of which I have outlined. First and always foremost come tyres and wheels. Here the basic needs and basic conditions remain the same as before the war.

Land Tyres and Wheels

For car and heavy vehicle tyres, designers and technicians continue to concentrate upon long life and resistance to wear concussion and accidental damage, non-skid properties and road holding under all conditions. Tread design is an example of what can be built into a tyre by the pooled knowledge and experience of many specialists. Appearance and fashion also receive as much expert attention as construction.

The maximum speed of the new cars is likely to be well in excess of the pre-war models. Now a speed of say, 85 m.p.h., subjects the tyres to a much greater stress than one of 55 to 60 m.p.h. Higher speeds increase the generation of heat and the rate of wear, so modern tyres have to be designed to counteract these influences and to ensure road-holding or "controlability" of the car, under all conditions, including

(the inevitable) fast cornering. The fast driver (with whom I could wish myself in closer sympathy), needs tyres that will give him comfortable driving combined with certainty of steering, in order that rapid changes of direction may be smoothly assured. The Company have special equipment and testing methods for the measurement and analysis of passengers' comfort, power consumption, skid resistance, noise, cornering power and tyre balance; therefore their supremacy in tyres for racing and record attempts, including the world's land speed record of 368.85 miles per hour, seems likely to continue.

Certain kinds of tyre call for very special properties. Dunlop make, for instance, an electrically conducting tyre for dispersing electrostatic charges. These have been standard tailwheel equipment on British aircraft throughout the war. Extensive tests have been made on Public Service vehicles, including trolley buses, which can be effectively "earthed" by electrically conducting tyres. Another electric vehicle which demands special tyre properties is the battery-driven truck. Here it is of the utmost importance that the power consumed should be small, so that the maximum mileage can be run on each battery charge. A recent Dunlop development new to this country, is the large-section motor-cycle tyre, for example the 4.75-16, which is standard equipment on a new de luxe model motor-cycle, the riding properties of which are reported to be very satisfactory.

There are also many little-known special uses of rubber tyres, both solid and pneumatic. For example, various farm vehicles and implements have improved their efficiency by using pneumatic instead of steel tyres. Dunlop supplies pneumatics for farm carts and trailers (animal and tractor drawn), ricklifters, cultivators, and spreaders. Large earthmover tyres, such as Dumpers, Scrapers and Graders, are also becoming more and more necessary for building and reconstruction work which is required as an aftermath of war.

Dunlop have designed and produced special tyres for all these purposes and hope to make use of the various welding processes evolved during the war for tank and military vehicle wheels in the construction of lighter and stronger road wheels for civilian purposes.

They have plans for meeting the world shortage of cycle rims by a swift increase of output; also for making rims for Sports use, in which the light alloys developed for aeroplanes will be employed—another instance of war experience being put to the good uses of peace.

Aeroplane Tyres

The extensive use of hard runways in Britain has resulted in the design and introduction of "high pressure" tyres. These have the advantages of being smaller and lighter in weight than the old larger section low pressure. To-day pressures of 90 lbs. per square inch replacing the 40 to 50 lb. per sq. in., are being investigated to assist the faster aircraft,

where thin wing sections and jet propulsion necessarily reduce the space for retractable wheels. For this purpose the Dunlop "Compacta," with a "low Crown" of squat sectional shape, provides a tyre which combines smallness and lightness with strength. This *multum in parvo* concentration is also being applied to the needs of British civil air liners. Furthermore, since the jet engine is likely to increase landing speed, much time and thought are being devoted to the design of new brakes for this purpose.

Tyres for Stratosphere Fighters

The problem of low temperatures in flying arose when improved aircraft engines and cleaner lines pushed the ceiling up to 40,000 feet, where temperatures of —60°C. or lower are encountered. After being frozen to rigidity at this temperature the tyres could hardly be expected to be capable of cushioning when the planes returned to earth only a few minutes later.

A thorough investigation was therefore made into the safe temperature limits for natural and synthetic aeroplane tyres, by duplicating the conditions of a rapid landing bump on a model tyre enclosed in a large refrigerator where the whole chilling cycle could be experienced. The results achieved were invaluable in aircraft design for high altitudes. The refrigerator is also in great demand for mechanical tests on other plane parts, such as multiple glass windows, oil pumps and jacks, all of which have to work at these very low temperatures.

The Test Flight is Formed

Dunlop has long maintained a fleet of cars for testing tyres. These run over two hundred miles a day, five days a week all the year round, testing the effect of different conditions of road surface and other conditions on different types of tyre. It was inevitable that if the Company was to render its full service to the aviation industry, similar steps must be taken to test aeroplane tyres.

It was not until July, 1944, that the Test Flight was formed, when M.A.P. allotted a Wellington aircraft for tests on the Compacta tyre. These were carried out at Baginton aerodrome, near Coventry, but it was soon realized that concrete runways were necessary for braking tests, and arrangements were made for a runway over 2,000 yards long at Honiley, near Kenilworth, where there have been over four hundred landings on Compacta tyres. An Albemarle, fitted with a tricycle undercarriage, arrived in March, 1945, for experimental work on wheels and brakes and has since made some 500 landings, testing new brake linings, brake drums and now, in addition, the new Dunlop Plate Brake. A Bristol Buckingham aircraft was also received some months ago, and on this in conjunction with the Research Division at Fort Dunlop, interesting work has been done on vibration problems with high pressure tyres, in order to increase comfort during taxying, and so to render civil flying

more pleasant for the passenger. The latest addition to the growing fleet is a four-engined Lancaster bomber, again to test the Compacta tyre, but of a much larger size than on the Wellington. Since this tyre will be used on the 120-ton Bristol Brabazon aeroplane, it has been considered necessary not only to carry out work on the 30-ton Lancaster, but on an even larger Lincoln bomber which will arrive shortly. With these five aircraft, the Flight Unit has grown from one engineer at Baginton, and the loan of a test pilot from the Sir Armstrong Whitworth Company, to 20 highly-skilled mechanics and two fully qualified and experienced test pilots at the Birmingham airport, Elmdon.

Flying Saves Time

A last word must be said for the Company's communication aircraft, the four-seated Proctor driven by a Gipsy Queen engine, bought in April of this year, and invaluable in matters of urgency. Recently a senior official of Aviation Division was taken to Gloucester, Christchurch, Slough and Luton in one day, the flying time being only 2 hours, 45 minutes. This enabled him to spend a considerable time with each of the manufacturers visited, and obtain valuable orders. He was back in his office by five p.m. On another occasion an urgent request was received from the De Havilland Company at Hatfield, at midday on Saturday. A Dunlop designer was taken down there in 40 minutes, transferred to a De Havilland Dove which took him on to Woodbridge, in Suffolk—another 30 minutes—returned to Hatfield and then to Birmingham. Although it was not until two p.m. that this journey was begun from Birmingham, the party were back by five p.m

General Rubber Goods

The goods produced by the Company outside the Tyre and Wheel Group are divided into two main sections: Producer goods, used in the preparation or production of a finished article; User goods: finished articles sold to the public, such as hot-water bottles, bathing helmets, household gloves, children's playballs and balloons, and the component parts of such articles. The manufacture of these is still subject to control in various ways, but we may hope that liberation is not far distant.

Producer goods are in heavy demand. Mechanization of coalfields has involved the increased use of heavy rubber conveyor belting of which it is likely for some years to come that the coal mines in this country alone will need double the quantity used before the war. Many of the country's industries, such as textiles, tanning, papermaking, news printing, have been working at low pressure. This they are now heightening, with a consequent demand for a larger quantity of heavy roller coverings than Dunlop have ever experienced. The manufacturing department is quickly being put in a position to meet this demand. Similarly the rehabilitation of chemical plants and new installations is

making a heavy call on the chemical plant lining department, and this is already being extended.

A large number of new uses for hoses and tubings have been created and have greatly enhanced the demand. It is being met. A small bore tubing for sheathing small diameter cable is being supplied for the new housing programme; and some fifteen miles of tubing in varying diameters is being delivered to I.C.I. weekly, for the manufacture of perspex. I.C.I. require also a quantity of wrapped hose, one and a half inch bore, for the manufacture of Penicillin.

The new washing machines now use a 2 feet 3 inch length of $\frac{3}{4}$-inch braided hose and also a 5 feet length of $\frac{1}{2}$-inch braided hose; and domestic utensils such as wringer rollers, vacuum cleaners, carpet sweepers and refrigerators, up to now in very short supply and crippled by purchase tax, create a heavy demand for small rubber components, which the Company will meet.

Adhesives

The technique in rubber and synthetic adhesives has grown considerably, and there is such room for extension that the Company contemplate laying down an entirely new plant for the adhesion of rubber to rubber, and rubber to wood.

Precision Bearings

Many lessons learned during wartime are in process of being applied commercially, and precision bearings of rubber bonded to metal, for the springing of cars, coaches, buses and aircraft, can now be applied. Their uses range (like that of the celebrated Nasmyth hammer which could crush a steel ingot or delicately crack a walnut) from the mounting of very fine instruments to the damping out of vibration in manufacturing plants laid on concrete or other foundations.

New Products

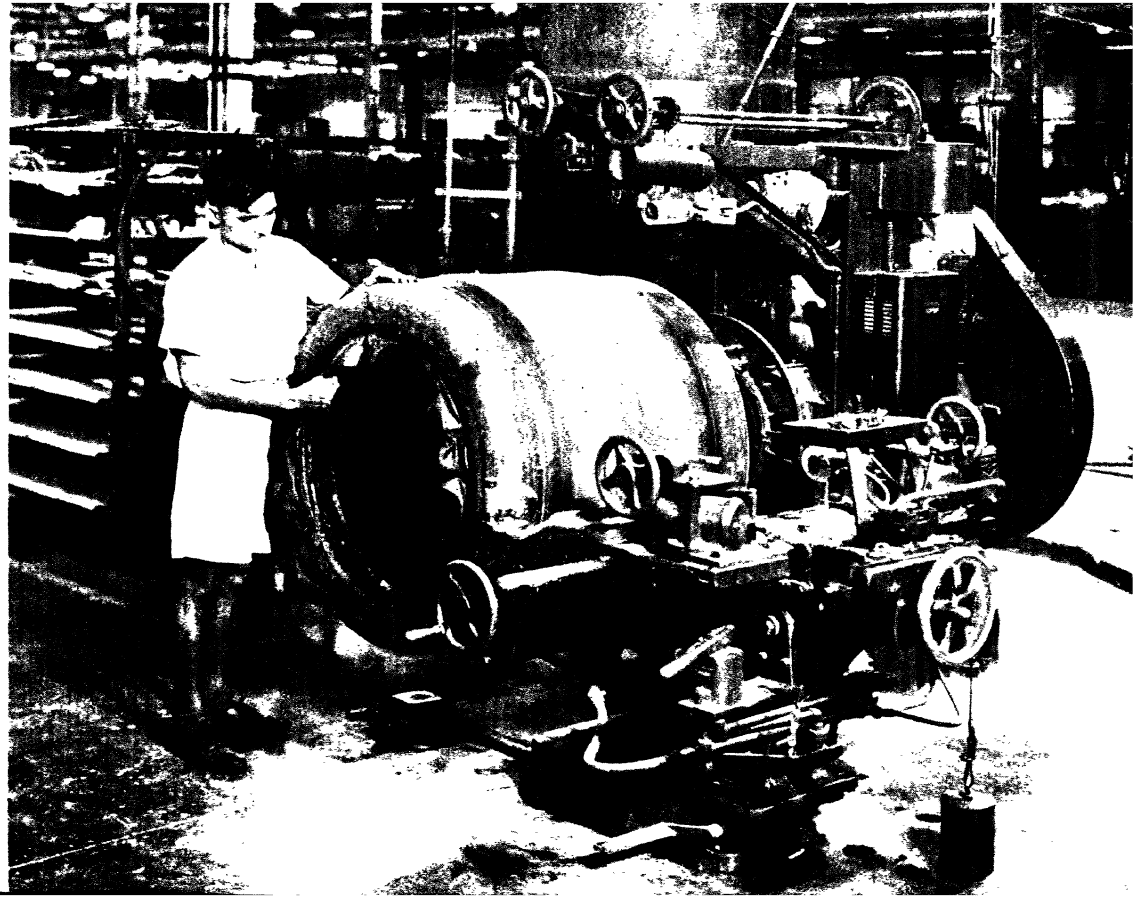
The Company hopes to evolve striking new products in addition to those consumer goods for which it is already famous: for example the application of electrically conductive rubbers and plastics to the local heating of surfaces (achieved by electrically heating a thin film of rubber or plastic paint) will provide heating screens for hospitals, heating-panels in household rooms, bed-warming panels, and de-frosting apparatus.

Clothing

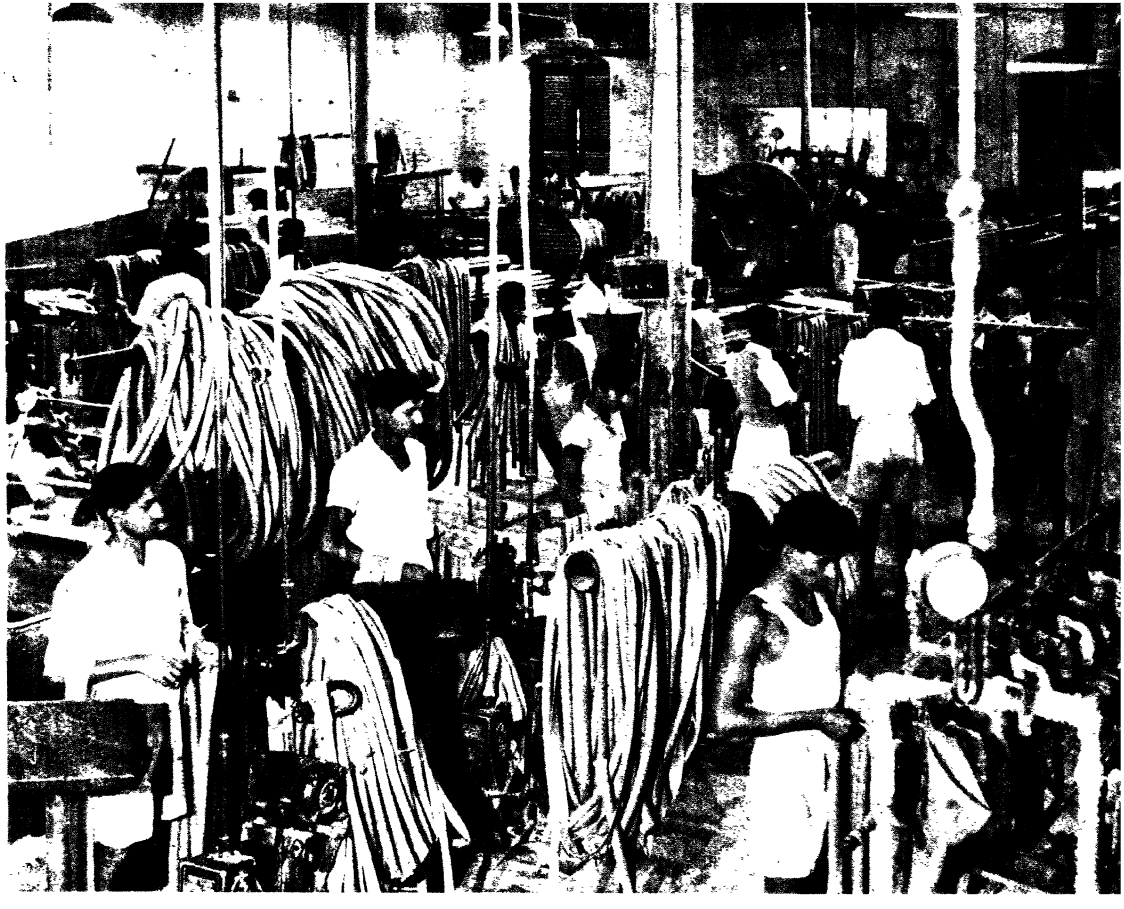
War experience with flexible plastics will give scope for new developments in the clothing field.

The war contribution of the Dunlop Clothing Division included millions of articles of clothing of different types for all services, such as

lling rubber at the Calcutta factory. See Chapter XV.)



Tyre building in Calcutta. See Chapter XV.)



Cycle-tyre tubes being manufactured in Calcutta.
(See Chapter XV.)

Above: The "Avro Avian." The first aircraft to be fitted with Dunlop patent brakes.
Below: The assembled Dunlop test flight at Elmdon airport.
(See Chapter XVII.)

battle dress, blouses, trousers, greatcoats, demob. clothing, snow and mountaineering clothing, ground sheets, special tropical clothing for the Middle and Far East campaigns, specialized tank suits, civil defence outer clothing for the women's services, W.R.N.S., A.T.S., W.A.A.F.S., and Civil Defence Nursing. This was something of a departure from the pre-war waterproof and sports clothing, and it gave the Company experience of which they mean to take every advantage in their post-war plans. They intend not only to continue every branch of sportswear outer clothing and Spectator Sports (which cover women's fashions as well as the treated fabrics) but are further expanding in men's suits; in extension of what they are now doing for the demobilized servicemen.

Footwear

The Footwear Division of the Company in the years before the war expanded its business by meeting a steadily increasing public demand for ordinary Plimsolls, sports shoes and holiday shoes for the summer, and for industrial rubber boots, Wellingtons, and other forms of winter protective footwear. Whilst most of this footwear was of the "utility" type, it was inevitable and natural that the Company's further development would take it into the field of fashion, particularly in women's footwear. In this sphere the lead had been taken before the war by the U.S.A. and by continental shoe manufacturers who derived their inspiration from the artistic centres of Paris and Vienna. Although the British industry was completely geared to the war machine—a fact which during the past seven years has enabled American manufacturers (who were but partially affected) temporarily to increase their lead—preparations are being rapidly made to take the fullest advantage of the discoveries of war-quickened scientific research (as for example in the plastic field) and of improved technical methods which were achieved as a result of the war effort. The importance of line and design is now fully realized, and the Company is making comprehensive plans to combine in its footwear factories the services of the designer and of the artist with those of the technician.

With scientifically constructed shoe lasts and fittings, and with newly established international contacts for styles and types, the Company, after an investigation of manufacturing processes and methods in America, is confident that all the conditions are being met to enable it to compete successfully at home and abroad with American and continental manufacturers in the production and distribution of stylish and attractive shoes.

Sports

The many successes already won in championships and tournaments with the Dunlop balls and equipment are evidence that the Company's supremacy in this field will be maintained. The demand for Sports Goods, especially golf and tennis balls, still greatly exceeds supply, and a per-

manent increase over pre-war levels is expected. To meet this Dunlop is concentrating manufacture at its great new factory at Speke, near Liverpool. This giant factory, with its up-to-date equipment and huge workshops, the largest of which are a quarter of a mile in length, will also help to carry out the expected increase in the demands for Dunlop's General Rubber Goods and Footwear. It is under the management of Mr. D. B. Collett, formerly Chief Labour Officer at Fort Dunlop, who acquired much valuable experience as Assistant Controller of the Midland Region of the Ministry of Labour during the war.

Floor Coverings

Dunlop expects that among its many new developments the products of its subsidiary, Semtex Ltd., will play an important part. These may almost be regarded as a war development, so much has been gained from wartime experience in the decking of ships and (oddly enough) from the compulsory use of substitute materials when supplies of rubber failed.

Although there are already many floor coverings for the architect or his client to choose from, the continuous or jointless floorings are only three: granolithic or terrazzo, based on hard unyielding and cold cements; magnesite which is corrosive, hard and liable to crack; and Semtex Fleximer, which overcomes all the disadvantages of the other types.

This flooring being slightly flexible does not crack easily, and even if small cuts or abrasions are made in the surface these heal under treading owing to its slightly plastic nature. It is warm, non-dusting and clean, qualities which will be enhanced as newer synthetic resins become commercially possible, because these have the advantages over rubber of oil-resistance and permanence.

Fleximer materials will be available in pleasing red, brown, buff, and green, as pigments once more become available. All Semtex Fleximers resist dampness to a degree not shown by any other flooring materials; they can even be laid on sites where dampness is known to rise through the floor, without deterioration to their composition. Other advantages are their firm adhesion to and non-corrosion of the sub-floor—features whose absence restricted the application of pre-war jointless flooring.

Semastic, a derivative from Semtex, is the name given to a new floor-tile, also manufactured by the Semtex Company. The tiles possess the properties of slight resiliency, flexibility, and self-healing characteristic of a mastic material. They are quite unlike the ceramic or the pre-cast terrazzo tile, being composed mainly of synthetic resins, a fibrous filler and special pigments. They are machine-cut to size in the factory so accurately that they can be fitted together without showing the joint. Because of their extreme durability they are made in thicknesses of $\frac{1}{8}$-inch and $\frac{3}{16}$-inch—all that is needed. To enhance the decorative effects of fitting the tiles into a design, a machine-cut strip is also made for bordering. Laying is easy, but a good and durable result requires the skill of a

man trained in the Semtex Laying School. Most floorings have their limitations for use: for rubber cannot be laid where there is grease or fat, nor linoleum where there is rising dampness. Semastic tiles, however, can be laid on almost any covered site.

These new developments will not in any way detract from Dunlop's activity in the field of rubber flooring, which has its own very important and desirable qualities.

Dunlopillo Cushioning

The Company is also keenly anticipating the return into general use of Dunlopillo cushioning. This, experts believe, is destined to achieve a leading place in domestic upholstery and in transport and theatre seating, which may enable it one day to rival tyres in the bulk of rubber consumed. Developments in the use of metal for furniture, which seem likely to result from war experience, and the improvement in methods of adhesion already mentioned, should all assist the development of this wonderful product.

The Human Factor

Britain is faced during the next few years with a shortage, certainly of juvenile labour, perhaps of labour generally. Nevertheless, if (as demanded by Government) we are to increase our exports by 75 per cent and to improve or even maintain our standard of living, we must produce more work per man. This means that the efficiency, intelligence and output of every worker must be increased and industry must be made much more attractive to the best brains of the nation than it has been before. A great improvement in education both general and vocational is therefore necessary, and will require the co-operation of industry, in which so large a proportion of our people find employment on leaving school. Realizing this, Dunlop began in 1943 to build up a comprehensive training and education scheme; and chose most happily as head of the organizing committee Sir Charles Tennyson, Secretary of the Company, a scholar as well as a business man.

The first object of the scheme was necessarily the retraining of the 7,000 employees who had left the Company during the war for national service. During the war years the rubber industry has passed through revolutionary changes, both technical and commercial, and these men would urgently need bringing up to date. Moreover there are many young men who had been in junior positions but who during their war service would have advanced in more ways than one and attained positions of responsibility. It was therefore decided to establish a special refresher training programme for those (including operatives) considered capable of assuming administrative and supervisory responsibility.

The training programme is divided into two parts—first a General Reception Course of one week at Fort Dunlop, and then a Divisional

Course or Courses in the particular Division to which each trainee will eventually be attached. For the Reception, some 45 men from various departments assemble at Fort Dunlop on a Monday morning, and the first item on the programme is a luncheon at which the Chair is taken by a Director of the Company who officially welcomes them and explains the nature of the Course. The rest of the week is given up to a series of lectures and factory visits, and the course closes with a very informal dinner at which the Chairman of the Committee generally presides.

One of the most valuable features of this Course is the opportunity it provides for men from different Divisions to meet and get to know one another; another, always the subject of favourable comment by the trainees, is that all the lectures delivered are by senior officials of the Company, many of whom have to travel to Birmingham from London, Manchester or Liverpool for the purpose. It is as though young Civil Servants found themselves addressed by Under-Secretaries of State.

At the time of writing, ten of these Reception Courses have been held and about 400 trainees have passed through them. All Service ranks have been represented, up to Brigadier in the Army, Group Captain in the R.A.F. and Commander in the Navy. Fifty of these men had achieved the rank of Major (or higher) or its equivalent in the other two Services.

The course has undoubtedly achieved its object in bringing the men up to date and making them realize the Company's wide scope and responsibilities. It has also been successful in promoting a spirit of good will and enthusiasm amongst those who have attended it, which holds great promise for the Company's future.

With this emergency scheme is being built up a permanent system of recruitment and training, which should enable the Company to maintain a really fine standard of membership in the difficult years to come.

Training Organization

The Training Organization consists of at least one Divisional Training Officer in each main Division, under the direction of the Chief Staff Training and Appointments Officer who is responsible to the Managing Director. His duties are to correlate the work of the Divisional Officers, to advise and assist the Divisions on all problems relating to recruitment and training and to interpret the Company's general policy for training and education. Twelve Divisional Training Officers have so far been appointed.

It is not the business of any industrial organization to provide educational or vocational training already supplied by established professional institutions such as Technical Colleges, Commercial Colleges, Schools of Art, Day Continuation Schools, etc. The Dunlop scheme is designed to derive the maximum advantage from such facilities and to encourage employees to make the most of the opportunities thus provided. On the

other hand training in Dunlop methods, practice, and processes can be provided only by the Company itself.

Training of Juveniles

About 80 per cent of the boys and girls in this country leave school at 14 years of age—to be advanced to 15 in 1947. Children of this age have had no "vocational training" at all, and with many the standard of general education has been deplorably low, particularly during the war years.

General Education

As is well known, the Government have planned the introduction of "County Colleges" which will be attended for one day per week (or its equivalent) by all boys and girls between 15 and 18 years of age. But the date when even the first of these County Colleges will be erected and in operation is still indefinite, and there seems to be very little chance of any serious progress in this direction being made before 1950. Meanwhile, the Directors of Dunlop, convinced of the advantages of continued education, have decided to anticipate the legal enforcement of this part of the Education Act and, wherever the necessary facilities can be provided, to make them available as soon as possible to all employees under 18. The magnitude of this decision will be appreciated when it is remembered that, under normal conditions of employment, something like 2,500 juveniles will be involved, distributed over areas governed by at least 20 different Education Authorities. Some difficulty is being experienced in securing the necessary facilities but the scheme has already been started in Birmingham, Manchester, Coventry, Dudley and Speke, where all employees of 14 (boys and girls, staff and operatives) are attending Continuation School classes for one day a week in the Company's time, during which they receive pay. In the next three years the training will be extended to employees of ages 15, 16 and 17, and other areas will be brought into the scheme as soon as possible. The curriculum is of a general educational type and includes such subjects as Mathematics, English, Physical Training, Handicrafts, Domestic Science, Current Events and Citizenship.

Vocational Training

At some stage in the career of many of these young workers general education should be replaced (or supplemented) by vocational training; though this may not be possible or necessary for some whose vocational training starts at 15.

Studentship Schemes

There are already three "Studentship" (or Apprenticeship) schemes for lads of special promise, operating respectively in the Tyre Engineering, the Rim and Wheel, and the Tyre Production Divisions.

In the Tyre Engineering Division most trainees pursue a similar course for the first 3 years after sixteen—through Machine Shop, Power Plant and Works Engineers Department. For the last two years of the full course of five years they specialize, qualifying as, for example, Turners, Millwrights, or Draughtsmen. Balance between practical and theoretical training is maintained by school studies in City and Guilds or National Certificate courses. Many qualify for the City of Birmingham Apprenticeship Certificate. At least one day a week is spent at a local Technical College, and parallel evening classes are regarded as essential. The practical training is carried out in the Engineering Departments at Fort Dunlop where some 1,500 engineers are employed practising more than a dozen recognized engineering crafts.

At its Rim and Wheel Works at Coventry, Dunlop offers a five-year Studentship Course in general engineering. This also starts at sixteen and is open to boys from elementary or secondary schools. Wages are paid at ordinary rates for the time spent at day classes and all tuition fees are paid by the Company. The course is fully recognized as an apprenticeship course by the City of Coventry and the local Engineering Association and Students who successfully complete it receive a special Apprenticeship Certificate which carries with it the Freedom of the City.

The Tyre Division differs from the above two; being far less of a standard apprenticeship scheme, because in the rubber industry it is unnecessary for a boy to go through a lengthy training in order to obtain a working knowledge of tyre-building, calender operating and rubber mixing. This course comprises three years' practical training in the factory, followed by two years' specialization in the work for which each student shows the greatest aptitude. Promising boys will be able to use the Studentship Course as a stepping stone to other divisions of the Organization.

Payment of Tuition Fees and Examination Awards

The object of Tuition Fee payment is to encourage the older employee to improve his qualifications by taking appropriate part-time courses of study at approved educational institutions. At the end of each Session the Company applies to the College for a report (the student's permission for this having been obtained on the enrolment form) and subsequently the course fee, or a portion of it, depending upon attendance and performance, is refunded.

Students who are successful in passing any of the recognized examinations are paid money awards in accordance with a fixed scale. These vary from £3 (City and Guilds of London Institute, Intermediate Grade) to £25 (University Degree). All the well-known examinations are included —the University examinations, the Ministry of Education National Certificates, and the examinations of the leading professional bodies.

Vacation Courses

Like other large industrial concerns, Dunlop offers facilities to University students who wish to take up temporary employment during the Long Vacation in order to gain practical experience. Engineering and Science students are temporarily employed in the Engineering Departments and Laboratories respectively; while men and women who are studying Industrial Administration are encouraged to take temporary work as factory operatives, and so to become familiar with working conditions in a large factory, to make contact with a large number of workers and to form some idea of their general mental attitude. Vacation Students engaged on the Staff are paid at the minimum rate for their age. Those working as operatives are paid at the appropriate rate for their work.

"T.W.I."

In January, 1944, the Ministry of Labour and National Service sent a representative to the U.S.A. to investigate a new training technique for Supervisors, reported to be most successful. On his return they decided that a modified version of this programme would be useful to British industry, and in September, 1944, the scheme was launched in Britain under the title of "Training Within Industry for Supervisors," more generally known as "T.W.I." It aims at developing skill of supervision on three essential lines—the skill of instruction (Job Instruction), the skill of handling workers (Job Relations) and the skill of improving methods (Job Methods).

T.W.I. is conducted by group conferences and is given inside the organization—usually by a "leader" who is a member of the staff. He attends a one-week intensive training course, known as "Institutes," in the programme selected. On completion of this course, the group conference leader returns to his own firm and is then in a position to conduct his own training groups. Dunlop was one of the first Companies in this country to take up "T.W.I." and operated "Job Instruction" at Fort Dunlop as early as November, 1944. The scheme has expanded rapidly, and there are now fifteen members of the Company's staff (including one at Montlucon, France) who have attended "Institutes" and qualified as group conference leaders in Job Instruction and are now applying these methods in Dunlop factories. One member of the staff has qualified in the "Job Relations" programme, training which has already started at Fort Dunlop. A "Job Methods" programme is also planned.

Training of Foremen

The Production Foreman occupies a key position in any manufacturing organization: as a link between Management and operatives he must be fully qualified to interpret the views of either of these to the other. The Company has introduced special courses for Foremen (and potential

Foremen) in four of its factories and proposes to extend them to other factories in the near future.

Divisional Courses

An important addition to the above is a comprehensive programme of "Divisional Training" in Dunlop subjects, which is now being planned in all Divisions of the Company, though not every division has yet completed its programme. The initial scheme of the Home Tyre Sales Division for juniors covers a period of about twelve months for the staff at Sales Depots, or two years for that at Headquarters and its aim is to provide the best possible grounding in the constitution and routine work of the Division. For the most promising boys recruited at Sales Depots this period ends with a spell at Headquarters.

Subsequent training for older selected candidates is available in various forms, as well as Refresher Courses for senior staff.

The training programme of the Overseas Department is of particular importance since it has to meet the requirements not only of the Headquarters staff in London, but also of members of the Overseas Staff from all parts of the world, many of whom make but infrequent visits to this country. The whole programme includes nine different Courses varying in length from four weeks to two years. The longest course of all is for promising new entrants to the Overseas Department. It provides a basic knowledge of the organization and products of the Company together with a more detailed knowledge of its Overseas activities, and occupies two years, in different branches of the Department.

The Technical and Special Product divisions are highly specialized Departments with a staff which includes rubber technologists, chemists, physicists, mathematicians, radiologists and many other skilled scientific workers. A large proportion are University graduates who join the Company's service comparatively late, i.e. at the end of their University careers, when their academic training may be considered complete or at any rate sufficiently advanced for application to the problems of industry. They now enter the important period of further training in the special subjects of the rubber industry, instruction in which can be given only by the Company's own experts. Each subject is dealt with by the Company's leading expert and ample time for discussion is allowed at the end of each lecture. Every opportunity also is taken of sending selected members of the staff to any lectures or exhibitions of interest which may be held in different parts of the country and to special courses which are offered from time to time by the various Universities in such subjects as colloid chemistry, rubber technology (in which the Company has founded a lectureship at Birmingham University), advanced physical chemistry, and chemical engineering.

"Bird's-eye View" Course

Finally, experiments are being made with a "Bird's-eye View" Course, the object of which (as its name implies) is to provide a view of

the Company's activities and organization as a whole. It lasts over four weeks and includes visits to Head Office, Overseas Department, two typical Sales Depots and fourteen factories. This is obviously an expensive course and its use is likely to be restricted to special entrants for whom a general picture of the Company's field of activities is considered desirable.

The preceding paragraphs by no means cover all the varied features of the Dunlop Training Scheme as it will ultimately develop. The Government's recent announcement regarding compulsory national service has introduced new problems which are being carefully studied. In a few months' time the Company hopes to have evolved comprehensive arrangements which will ensure so far as possible the fullest development and utilization of the human capacity available to the management, and will make every Dunlop employee feel that the Company is trying to make the best of him and to do the best for him.

Industry works by machines; but with variety and opportunity of special and general enhancement on this scale, no industrialist of any rank has any excuse for thinking, or living, mechanically.

Dunlop Overseas

The possibilities which the future may hold for Dunlop Overseas would require a separate book since, as I have mentioned in Chapter V, each market has its own special problem, to which there is no general solution. I can only indicate certain tendencies and illustrate them with a few examples.

Overseas trade is not an end in itself, but a means whereby countries are able to produce supplies of vital commodities which they cannot obtain in sufficient quantity from resources within their own borders. The need of Great Britain with its high density of population for imported food and raw materials has been so continually emphasized in recent months that I need not enlarge upon it. To import these supplies we have got to export goods or perform services such as shipping and insurance to an equivalent value. Failure to do this could only result in a serious fall in our standard of living.

The function of the Dunlop Overseas Organization in the future is thus clear. It has to secure, by the sale of its many products, as much as it possibly can of the resources needed to purchase the food and raw materials which this country must have.

Of the two methods of meeting the needs of overseas markets, namely export from the United Kingdom or manufacture on the spot, it is clear that the national interest requires Dunlop to export wherever possible. Export is obviously more remunerative for the nation than local overseas manufacture, but the difference may not be so great as one would at first think.

Before we can export rubber manufactures, we must import rubber and cotton. It follows that the value of a shipment of tyres, for example,

for the purchase of materials from abroad, is not their total selling price, but that price minus at least the cost of the rubber and cotton used in them. This difference is the value put into the finished articles by British brains and brawn.

Moreover the usefulness of local manufacture overseas is not limited to the goods which can be purchased and brought to Britain by means of the profit earned in the overseas markets where factories are set up. We must remember that, when the factory was being built, considerable sums were spent in this country in the purchase of machinery and that, when the factory is in full operation, not only replacements of machinery but also some of the materials used in manufacture can be obtained from Britain. For example, an appreciable proportion of the output of the Dunlop Cotton Mills at Rochdale went, before the war, to Dunlop factories overseas. During the war, of course, the overseas factories had to depend a great deal on local materials but it will undoubtedly be the policy of the Dunlop Board to promote the use of British materials as much as possible.

I have emphasised the value to Britain of the overseas factories because it is a problem very much to the fore in the rubber manufacturing industry. It is only natural that national tendencies to industrial self-sufficiency should have been strengthened as a result of the war. Even without the rubber shortage nations lacking a rubber manufacturing industry would still have been desperately short of essential rubber products. Encouragement is therefore being given in many parts of the world to the establishment of local manufacture.

Against this tendency we must set the general desire for freer trade. The results of this tendency may involve reconsideration of certain manufacturing profits which would need high tariff protection to maintain them; but the extension of manufacturing projects overseas is likely to continue, though perhaps at a slower tempo.

The Dunlop Company is well placed to meet these conditions, with its associated factories in Australia, Canada, Eire, France, India, South Africa and the U.S.A. It also has factories in Germany and Japan and is now building a factory in New Zealand. Arrangements for the manufacture of many Dunlop products in other factories have been made and are working successfully in Argentina, Brazil, Peru and Sweden. Similar arrangements existed in Java before the war, but the future of rubber manufacture in that part of the world is at present uncertain. All these manufacturing units will be engaged in meeting the local demand for Dunlop products. The French factory is the only one with a large export trade, mainly to the French colonies. All look to the future with confidence, despite the increases in manufacturing capacity which took place in many of their countries during the war and the knowledge that nearly all of them have to face additional competition. The reason for this confidence is easy to see. Most of them are in countries of great distances, where the demand for motor vehicles is still far from satisfied.

The pneumatic tyre is the main product of all of them and they can look forward to a steadily increasing demand. Exception must be made for Germany and Japan, whose future is difficult to forecast. Special mention must also be made of France, where exceptional difficulties have had to be met. The success of the French Dunlop Company in preventing the resumption of large-scale production after the 1943 bombing (*see* Chapter XV) handicapped it after the liberation. Nevertheless, enormous strides have been made since then and the beginning of 1947 should see production back at the pre-war level.

In discussing the future of these factories, I have given pride of place to the pneumatic tyre. This is only natural since it was invented by the founders of the Company and is still the most important item manufactured. I do not wish however to give the impression that the other items are unimportant to the overseas factories. Far from it—all of them manufacture other items and some, Australia for example, have almost as long a list of products as the home company itself.

This brings me to a point of some importance in connection with the establishment of overseas factories. In several places the local demand for certain items made in the British factories is insufficient to justify local manufacture, but nevertheless constitutes very useful business. Such items can be imported from Britain and sold through the powerful local sales organization in quantities which would have been impossible had not the local factory, and consequently the sales organization, existed.

To return to our study of the future, the fact that so many production units are already well established overseas makes it possible for the Dunlop Board to view the prospect of local manufacture in other countries without alarm. There are, of course, several countries with rubber manufacturing industries, where Dunlop has not yet made arrangements for the manufacture of its products. The smaller countries of Europe, such as Belgium, Holland and Switzerland are instances. Tyres and other rubber products have been manufactured there for many years but the Company has found it possible to sell its British made products on a scale which has justified the establishment of associated companies as Dunlop importers. The position may not always be so happy, but the successful solution of the problem of local manufacture in so many important markets ensures time to study other markets one by one, wherever there appears to be a threat to the continued sale of British Dunlop goods.

The future will undoubtedly bring with it increased manufacture outside Europe. I have already mentioned New Zealand, where the new Dunlop factory, although one of several, will add considerably to the Company's strength in that Dominion. It is too early at present to suggest other possible extensions of overseas manufacture, but the Company has several possibilities in mind which it is studying with a view to action when conditions are suitable.

Turning now to the markets where Dunlop sells the products of its British factories, there is every reason to look forward to steadily increasing sales. The present situation of acute scarcity of goods and of short supplies is, of course, temporary, but when the shortages have been met, the use of many rubber products is certain to increase in most countries.

In Europe, Denmark and Norway are already well on the way to recovery and, despite a modest manufacture of tyres by Danish and Norwegian companies, should offer excellent opportunities for Dunlop. The future in Eastern and South-Eastern Europe is less bright. These areas were poor before the war and the repair of the devastation of war will take all the energies of the inhabitants—assuming they are left free to exert them—for some years to come. The political future is uncertain and the ability of these countries to import manufactured goods from Britain will depend on their success in disposing of their agricultural produce—always a difficult problem and one which made several of them little more than German puppets even before the war started. The Dunlop Company will certainly not miss any opportunities in these markets, but will view the future of its business there with caution.

There is no lack of problems in other parts of the world, but their long term outlook seems more hopeful. In Malaya and China, for example, Dunlop is re-establishing the associated companies whose existence was interrupted by the Japanese war. China, in particular, has enormous possibilities of development, once internal unity is achieved. Even to-day, transport and its needs are more important there than they were before the "incident" of 1937. The Japanese invasion, destructive as it was in the seaboard areas, brought development, if only for strategic purposes, to the long-neglected south-west. Roads were built where previously there were only tracks, and the motor lorry is now a common object in many districts where only a few years ago it was never seen.

Throughout the Near and Middle East also, the development of motor-roads has been much accelerated by the necessities of war. Improved transport should bring many benefits to the people of these regions, and to Dunlop it will bring an immediate demand for tyres and, in due course, as the benefits of improved transport make themselves felt, a demand for other Dunlop products as well.

I have already mentioned the Netherlands East Indies in connection with Dunlop's arrangements for the manufacture of some of its products in Java. The political situation is still uncertain and it is likely to remain so for a little time to come but, once a measure of stability is restored, the local Dunlop organization will be re-established. The islands have immense potential wealth, the development of which should lead to a rising standard of living, once the ravages of the Japanese occupation have been repaired, and to an increasing demand for manufactured goods of all kinds.

By comparision with other continents, much of Africa remains

backward and poor, but, even here, the war was not without its benefits. The demand for many of the products of tropical Africa increased considerably as a result of the Japanese occupation of so much of the Far East, and many improvements in transport had to be made to ensure collection and shipment. The war in North Africa emphasised the importance of West and Central Africa as a line of communication and led to the building of numerous airfields across the continent.

Not all of these changes can be permanent, but many will be of lasting benefit to the inhabitants and will make possible an improvement in economic and social conditions in areas previously out of touch with civilization. The far-sighted Colonial Development Fund (initiated by Mr. L. S. Amery, when Colonial Secretary, nineteen years ago) will also be an important means of advance in British colonies. The pace of the general advance cannot be rapid, but in those countries whose chief problem is the great distance between centres of population transport is certain to come first. Dunlop can therefore look for an early increase in the demand for its tyres and transport accessories, followed gradually by the demand for its other products.

I have left Latin America to the end of this brief review of world conditions, because, as previously observed, so many parts of the continent already possess their own rubber manufacturing industries. The nations of Central and South America are naturally influenced by the United States, whose exporters have therefore an advantage over their British cousins. This advantage was increased in the countries where Dunlop products are not manufactured on the spot, because war-time controls reduced British exports to Latin America to a thin trickle. But the Dunlop Company was quick to appreciate the importance of renewing its contact with its distributors there and, even before the war ended, two of its officials made goodwill tours over much of the area.

They found that the interest in British goods in general and Dunlop products in particular, was as great as ever—an interest which augurs well for the future. Since the control of exports from Britain has been relaxed, an appreciable portion of the limited supplies available has been directed to Latin American countries and there is every ground to expect that, as soon as adequate supplies are available, the Company's position will be at least as good as it was before the war.

Before concluding this chapter, I should like to add a word or two about staff. The war created many difficult problems. Young men who, after a period of training in Britain, would normally have gone overseas to take up junior positions, were called to the armed forces; some of those already overseas, particularly in the Dominions and India, were also called up or summoned to important Government work; while those remaining had to face extra work without home leave, frequently under trying climatic conditions. The result has been a serious shortage of trained staff.

The Dunlop overseas official has to be carefully chosen and prepared;

particularly in territories which do not justify the formation of an associated company with adequate staff. There he is not merely the Representative, but, to the inhabitants, the Dunlop Company itself. The Organization has engaged a number of new men who are now being trained to take up positions overseas. Pre-war employees back from the forces undergo refresher courses to bring their knowledge of Dunlop and its products up to date. All of these will go out to the overseas markets as part of an organization which, although it has suffered during the war, has no doubts that it can regain and surpass its former position in the world's rubber industry.

EPILOGUE

They shall beat their swords into plowshares, and their spears into pruning hooks . . . —*Isaiah* 2, *iv.*

"IN my end is my beginning." When I undertook this book I little realized the peace scope of the Dunlop Organization—far less, the part it has played in the war; without which (and its like) the heroism of our men on a hundred fronts of land, sea and air would have availed them about as much as did that of the Dervishes before the machine-guns at Omdurman. Suddenly to scrap a great peace-industry and to remould it, decimated and against time, for the needs of war with daily and nightly destruction raining upon it from the heavens; as suddenly to lose nine-tenths of the vital creative essence of their activities—these were surely, for the highest as for the lowest, heart-breaking, back-breaking experiences of blood, sweat and tears. The more I learnt of swift replanning and loyal fulfilment, the deeper grew my admiration for the brains, character and endurance of all ranks in this great public service.

This compilation has attempted to record and to describe war effort and war production. Of these two the first is the common theme of books published in civilized countries for the past six years; while the second permits, invites—sometimes demands—a degree of technical explanation which might have clogged the pen of Kipling himself. *McAndrew's Hymn* is of machinery, and machines are often fantastically variegated, individual and alive—even human—whereas their myriad offspring, though marvels of research and inventive ingenuity, are all too often prosaic, undecorative objects, "as like as two peas" (or twenty million), appreciable only after recital of their qualities, merits and "performance"—like a tedious person whose virtues are real indeed, but buried beneath an undistinguished surface.

But wars are not won by the picturesque, nor civilization maintained, though it may well be enhanced when peace shall have restored to our industries the creation of interest and beauty in form, line, colour, comfort and repose.

I am left, as I said, with an overwhelming impression of concentrated, yet far-flung almost universal fine intelligence; organized for the amenities of life yet able in a flash to transform itself, and them, to the necessities of life preservation. Yet I find myself almost resentful (as I fear the reader may well have become) of the hammer-like but unavoidable high frequency repetition of the name of Dunlop. Here is one of the penalties of greatness. Many another company, not one-tenth perhaps of this scale and scope, sells its products under a dozen different and seemingly

unconnected titles, whose identity and cash nexus is known to a few initiates—not always including the shareholders. They are as unsuspected and surprising as the gods of antiquity, where the attributes and entity of Zeus—"many-named and many-templed"—subsist equally under the style of Jupiter, Osiris, Moloch or Baal. Pomposo cigarettes, Elephant Brand and Gay Gasper Blend sold respectively in Bond Street, Peckham Rye or Blackpool, appear to offer (often from the same leaf) a variety of choice agreeable to advertiser, vendor and consumer alike.

On the other hand, for the name and fame of all its goods, products, articles, types or grades, ranges or lines, features, developments (industry is desperately rich in such synonyms) wherever made and by whomsoever sold, there is no Dunlop but Dunlop. The golfer and tennis-player, cyclist, motorist and aviator, delicately-nurtured female and busy housewife—all find Dunlop inerasably displayed upon their golf and tennis balls (and rackets), tyres small and great, raincoats, Wellingtons, mattresses, hot-water bottles or rubber gloves. He pursues you as inevitably, as inexorably, in your daily life as he pursued me, sometimes to my dismay, throughout the pages of this book. With the ultimate result that, as a friend remarked to me the other day, Dunlop is in some ways the best-known name in the world.

It was the sort of remark that, as they say, sets one thinking, and I at once tried to think of universally better-known names. Excluding the past—for Shakespeare himself can count as little in China or Central Africa as, say, Wellington in the Middle West—and restricting the search to the living or recently living, I was confronted, obviously, by Churchill, Roosevelt and Stalin who must, as obviously, be accorded pride of place. But will historic characters remain emergent in the civilization of the future, when the past will yield an ever higher precedence to the present? In the absence of any decisive "Gallup" or "Fortune" World Poll, I grow less and less certain that my friend was wrong.

The prestige of this single name carries with it not only a high stimulus, but a warning. Should "Gay Gasper" deteriorate, attention can be deflected upon "Elephant" or "Pomposo" and other names registered for the same company—perhaps for the same quality. But the failure of any one of Dunlop's more important manufactures might well discredit all. So far there has been no failure. Dunlop has not been found wanting, in peace or in war.

This factual account of acknowledged services to the Kingdom, the Empire, the Allies—to the cause of freedom, is historically significant as showing what the Western world and in particular, the British Empire, could achieve in the heyday of Capitalism; nor is it easy to see how such things could have been achieved under any system lacking the incentives of enterprise, of competition, above all of personality. The vast being of Dunlop is in effect a Department of Works that really produces work, a constructive Civil Service (if one can imagine this) functioning without the standard percentage of undismissible ineffectives playing for risk-less, effortless safety; without sealing wax or red tape or their unchallenge-

able delays; without even the clinking processions of elevenses from 9 a.m. to 6 p.m.—which characterize the best Civil Service hitherto evolved. Dunlop is, and will be more and more, a Service not only instructed and trained to increase individual and collective usefulness, and chances of high promotion, but educated to enrich the private and the social life of every citizen member. Only those who have studied at first hand the baleful attraction and deadening results of Government Service (with a virtual monopoly of opportunity and influence) in some Latin and Oriental countries, can fully realize the advantages to the individual and (even more) to the State of such interesting and honourable alternatives.

Any group of workers that in a hundred ways enhances daily life all over the world, at work and at play, waking and sleeping, deserves well of its fellows and will surely prosper. Any that makes safe the path of man by land, or his alighting from the air upon land or sea, is not only enhancing, but preserving life.

Second only to Prometheus, discoverer of fire, comes surely the unknown inventor of the wheel. Fire or any "thermal process" with the wheel it makes or speeds was, and must remain, the basis of material civilization. And while wheels continue to run upon earth—I suspect that there'll always be a Dunlop.

GLOSSARY

ACCELERATOR.—Agent used for speeding up the rate of vulcanization.

ANTIOXIDANTS.—Chemical substances which retard the rate of oxidation.

AUTOCLAVE.—A steam vessel fitted with a vertical hydraulic ram used for moulding and vulcanizing at the same time a number of covers each in a separate mould.

BANBURY MIXER.—A closed type of mixing machine or internal mixer in which the compounding ingredients are mixed with the rubber by means of heavy internal rotors.

BIAS.—The angle at which tyre cord fabric is cut with respect to the edge of the roll of material. The plies in the finished cover then have their cords at the desired angle.

BREAKER STRIP.—A band of rubbered open-woven fabric encircling a tyre between the tread and the topmost casing ply, to protect the casing from the direct force of road shocks.

BUTYL RUBBER.—A "synthetic rubber" obtained by polymerization from certain petroleum products. It has not the general purpose properties of G.R.S., or the oil-resistance of Neoprene and Perbunan, but it has, however, a high resistance to permeation by air.

CAOUTCHOUC.—The French name for rubber; the word in English is usually applied to the pure rubber hydrocarbon (a combination of hydrogen and carbon) which is the chief and essential constituent of natural rubber.

CALENDER.—Plant for processing and applying a thin film of rubber to tyre cord.

CARBON BLACK.—Carbon used as a rubber compounding ingredient, notably in tyre treads. It is obtained from several sources—by burning natural gas, acetylene, crude oil, or organic matter. Besides pigmenting the rubber black, it has great reinforcing properties, which vary with the way in which the black is manufactured. (*See also* "GAS BLACK").

CHAFER STRIP.—A strip of square-woven rubbered fabric covering the outside of a tyre bead from the toe to a point a little above the rim line. Its purpose is to prevent chafing of the bead by the rim.

COAGULATION.—The separation of the rubber substances from the watery part of latex. It is usually brought about by adding a coagulant, such as a dilute acid.

COMPOUND.—Rubber prepared by mixing with suitable ingredients to give it the desired properties.

CONDUCTIVITY.—The ability of a material to allow the passage of heat (thermal conductivity) or electricity (electrical conductivity). Rubber is normally a very good electrical insulator (non-conductor) but can be made electrically conductive by special treatment.

CORD DIPPING.—A process of immersion and subsequent drying by which cord is coated (before calendering) with a substance that promotes its adhesion to rubber.

CURING BAG.—A heavy rubber bag shaped to fit inside a tyre casing before vulcanization, replacing the former on which it is built. The bag is then inflated and assists in shaping the tyre before and during cure.

CUSHION.—A thick layer of relatively soft rubber placed below or above a tyre breaker strip to improve the union between tread and casing, and to help in protecting the casing from shocks.

DIPPING.—*See* "CORD DIPPING."

EBONITE.—Vulcanite, or hard rubber, made by vulcanizing rubber with up to about 30 per cent of sulphur, as opposed to soft rubber with up to 5 per cent.

ELECTRON MICROSCOPE.—An instrument for magnifying up to 20,000 times by the use of a beam of electrons (electrically charged atomic particles) instead of a beam of light. The electron beam gives an image of objects too small to be seen in an ordinary microscope.

EXTENDERS.—Rubber compounding ingredients of a plastic or "rubbery" nature, usually derived from petroleum or vegetable oils. Used mainly for partial replacement or natural or synthetic rubber to conserve supplies of these materials.

EXTRUDING.—The forcing of plastic materials, such as unvulcanized rubber, through a die, to produce continuous lengths of a required shape. Tyre treads and inner tubes are made in this way.

FRICTIONING.—Impregnating fabric with rubber by passing fabric and thin sheet compounded rubber simultaneously between calender rolls revolving at different speeds, so that the rubber is pressed between the cords.

FORMER.—A metal or wooden support on which a tyre casing or other product is built.

GAS (CHANNEL) BLACK.—Carbon black or soot obtained by burning natural gas from petroleum deposits. Gas black is one of the best substances known for reinforcing rubber, and is particularly useful in imparting resistance to wear, as in tyre treads.

G.R.-I.—Butyl rubber.

G.R.-S.—*See* "SYNTHETIC RUBBER."

GUTTA-PERCHA.—A substance obtained from the latex of trees in the Far East. It is used for insulation purposes and in the manufacture of golf balls. It has certain rubber-like properties but differs in many respects. *Balata* is a similar substance obtained from South America.

HEVEA BRASILIENSIS.—The Latin name of the species of tree from which nealy all commercial natural rubber is normally obtained (*See* "LATEX").

HYCAR.—*See* "SYNTHETIC RUBBER."

INSULATION STRIP.—A strip of rubber sometimes placed between plies to insulate the cords of one ply from the next, and so prevent chafing.

LATEX.—A milky juice obtained from certain plants, of which the tree *Hevea Brasiliensis* is the most important. Hevea latex consists of rubber globules or particles suspended in a watery liquid.

"LASTEX."—Is a fine yarn made of rubber thread one-sixtieth of an inch in diameter or less, covered with cotton or other fibrous yarn. The rubber thread is made directly from latex by an extruding process. It is a special product of a company of which Dunlop and the United States Rubber Company are joint proprietors and is a good example of Anglo-American co-operation. It will be seen that the swimming suit incorporated two specialized Dunlop products not made by anyone else; namely "Lastex" yarn and D.T.C.10 sheeting.

LONG STAPLE COTTON.—Cotton with comparatively long individual fibres.

MANDREL.—In inner tube manufacture, a hollow former on which the tube is vulcanized.

MASTIC.—A resinous or bituminous compound, particularly used for flooring and paving.

MASTICATION.—Working or breaking down raw rubber between heavy roller to make it soft and plastic and ready for mixing.

MILL.—An open type of machine consisting of heavy revolving rolls for masticating or mixing rubber.

OXIDATION.—A chemical change resulting (usually) from the action of oxygen, as in ageing or weathering through exposure to air. The properties of rubber generally deteriorate with oxidation.

PALE CRÊPE.—The best quality of unsmoked plantation rubber, prepared in the form of thin crinkled sheets by passing freshly coagulated latex through compression rollers.

PERBUNAN.—*See* "SYNTHETIC RUBBER."

PERMANENT SET.—Though an elastic material such as rubber returns very nearly to its original shape after being stretched or deformed, it does not quite do so: the amount by which it fails to return to the original (for example, the difference in length before stretching and after releasing) is called the permanent set.

PERMEABLE.—Allowing air or other gases to seep gradually through.

PLASTICS.—Synthetic materials which are plastic, either in their final form, or which have passed through a plastic stage at some point in their manufacture.

PLASTICISERS.—Materials which facilitate the process necessary to render the rubber plastic.

RECLAIM, OR RECLAIMED RUBBER.—Scrap rubber which has been softened by a heat treatment and so made into a useful compounding ingredient. There are several types according to the class of scrap used and the type of treatment to which it is submitted.

RESILIENCE.—The elastic energy of a material, that is to say, the proportion of energy returned after straining an elastic substance as compared with the amount of energy used in straining it. The height of rebound of a tennis ball dropped from a certain height is a measure of its resilience.

RUBBER HYDROCARBON.—*See* "CAOUTCHOUC."

SMOKED SHEET.—Plantation sheet rubber dried by smoking, the most common form of commercial natural rubber.

SPREADING.—Coating fabric with rubber by applying the desired compound as a dough or thick solution, the compound being spread over the fabric as it passes between a roller and a knife edge.

SYNTHETIC RUBBER

(a) G. R. - S.—Government-Rubber Substitute.
The type of synthetic rubber produced in large quantities in America as a general-purpose substitute for natural rubber. Like the natural product its constituents are carbon and hydrogen.

(b) PERBUNAN
A synthetic rubber resembling natural rubber and G.R.-S., but superior to these substances in oil-resisting properties.

(c) HYCAR
A trade name covering a variety of synthetic rubbers. Hycar O.R. resembles Perbunan, and Hycar O.S. is similar to G.R.-S.

(d) THIOKOL
A synthetic material of a different type from G.R.-S. or Perbunan, possessing rubbery characteristics, and made from certain chemicals containing sulphur and carbon. It possesses high oil-resistance.

(e) NEOPRENE
Another rubbery synthetic, containing chlorine as well as carbon and hydrogen. Some types of synthetic rubber, e.g., Perbunan, Hycar O.R., Thiokol and Neoprene are markedly superior to natural rubber in oil-resistance. Perbunan and Hycar O.R. are used for such materials as petrol hose, carburetter diaphragms and gaskets, seals and washers exposed to oils or grease. Thiokol and Neoprene, are employed for flexible fuel tanks. Neoprene, because of better heat-resisting properties than natural rubber, is useful for aero brake tubes. Inner tubes can be made from Butyl or G.R.-I., a synthetic rubber having extremely low permeability to air.

TENSILE STRENGTH.—The force per unit area required to stretch a material to breaking-point. It is one of the most commonly used measures of quality in rubber testing.

THIOKOL.—*See* "SYNTHETIC RUBBER."

TOPPING.—Coating fabric with rubber by passing fabric and thin sheet compounded rubber simultaneously between calender rolls revolving at the same speed, so that the rubber is pressed on to the fabric (and not forced between the cord as in frictioning).

VULCANIZATION.—The process which changes raw rubber into a material suitable for practical use, by making it more elastic and less plastic, and improving its physical properties generally. These changes are usually effected by heating mixtures of rubber and sulphur, as in the steam curing of tyres and other articles, but other substances instead of sulphur are occasionally used.

VULCANITE.—*See* "EBONITE."

WEFTLESS CORD FABRIC.—Cord fabric formed without weaving (i.e. having no cross or weft threads), the cords being held together by the rubber applied to each side of the sheet.

WOVEN CORD FABRIC.—Fabric made by the older process of weaving a sheet or warp of cords which are held together by fine cross weft threads spaced at intervals.

ZINC OXIDE.—A white chemical which is one of the most useful reinforcing agents for rubber. It assists vulcanization, improves resilience, and can also be used as a white pigment.

AWARDS

List of Dunlop Employees who have received decorations and other distinctions for War Service or Civil Defence Service

The Most Excellent Order of the British Empire.

Officers (O.B.E.)

L. S. Faulkner, Wing Commander, R.A.F.	Tyre Sales Division.
R. Geddes, Group Captain, R.A.F.	Deputy Director, Overseas Sales.
J. H. Gurney, Sergeant, R.E.	L.Y. & L.T. Dept., Fort Dunlop.
R. C. Hiam, Brigadier, R.A.O.C.	General Sales Manager, Sports Division.
E. F. Hingeley, Commander, R.N.V.R.	Overseas Sales Manager.
M. C. Johnson, Lieut.-Colonel	
H. E. Hopcroft, Lieut.-Colonel, R.A.S.C.	Tyre Sales Division.
D. S. Robinson, Brigadier, R.A.O.C.	Sales Manager, South Africa.
E. Stanton, Lieut.-Colonel, R.E.	Fort Dunlop.

Members (M.B.E.)

D. A. C. Bennett, Major	Overseas Dept.
I. G. Cameron, Lieut.-Colonel	Tyre Sales Division, Fort Dunlop.
L. W. Greenberry, Major, R.A.S.C.	Tyre Sales Division, Liverpool.
J. B. Y. Hill, Major	Tyre Sales Division, London.
G. H. Way, Colonel, R.A.O.C.	Manager, Base Stores, Fort Dunlop.

The Distinguished Service Order (D.S.O.)

C. S. Morice, Group Captain, R.A.F.	Sales Manager, Aviation Division.

The Military Cross (M.C.)

I. Cotgreave, Lieut., King's (Liverpool) Regt.	Accounts Dept., Walton.
A. C. Davies, Lieut.	Dunlop Scholarship.
M. R. Strivens, Major	Giant Cover Dept., Fort Dunlop.

The Distinguished Flying Cross (D.F.C.)

W. Benton, Flight-Lieut., R.A.F.	Methods & Equipment Dept., Fort Dunlop.
J. Etchells, Squadron-Leader, R.A.F.	Semtex Limited.
H. R. Leven, Pilot Officer, R.A.F.	Overseas Dept.
H. J. T. Playford	Accounts Dept., Edmonton.
J. Sanders, Flight-Lieut., R.A.F. (D.F.C. and Bar)	Pattern Shop, Fort Dunlop.
C. E. Young, Flight-Lieut., R.A.F.	Tyre Sales Division, Southampton.

Medal for Distinguished Conduct in the Field (D.C.M.)

B. A. Brown, Major, Argyll & Sutherland Highlanders	Tyre Sales Division, London.
W. Hayward	

Distinguished Service Medal (D.S.M.)

S. J. Downey, Telegraphist, R.N.V.R.	Sub-Foreman, Walton.
J. D. Turner, R.N.	Base Stores, Fort Dunlop.

Military Medal (M.M.)

T. A. Brown	Mill Room, Walton.
A. N. Fraser, Sergeant	Tyre Sales Division, Birmingham Depot.
C. Jones, Sergeant	Stock Section, Footwear Division.
J. McQuillen, Sergeant, King's Regt.	
N. F. Moore, Gunner, R.A.	Tyre Sales Division, Fort Dunlop.
E. Robinson	Clothing Division, Edmonton.
I. P. Shotton, Sergeant, R.E.	Scrap and Reclaim Dept., Fort Dunlop.
A. Woollaston, Private	Mill Department, Fort Dunlop.

Distinguished Flying Medal (D.F.M.)

G. H. Britland, Flight Sergeant, R.A.F.	Supplies Dept., Fort Dunlop.
H. R. Leven, Pilot Officer, R.A.F.	Overseas Dept.

Air Force Medal (A.F.M.)

J. C. Gillon, Flying Officer, R.A.F.	Rim & Wheel Co., Foleshill.

George Medal (G.M.)

W. A. Jones, Sergeant, R.E.	Statistical Dept., Fort Dunlop.

The British Empire Medal (B.E.M.)

W. H. E. Grove, Home Guard	Tyre Sales Division, Norwich.
A. T. Richardson, Corporal, R.A.M.C.	Motor Cover Dept., Fort Dunlop.

Mentioned in Despatches.

W. S. Alexander, Sergeant, R.A.F.	India Tyre & Rubber Co., Ltd.
J. Angell, Petty Officer, R.N.	
C. A. Ayling, Wing Commander, R.A.F.	Overseas Dept.
F. Capstick, Lieut. R.N.V.R.	Laboratories, Cambridge St., Manchester.
A. Dowell, Sergt., Royal Corps of Signals	Giant Cover Dept., Fort Dunlop.
W. Eaton, Sergt., R.E.	Footwear Finishing & Packing Dept., Speke.
F. G. Eaves, Gunner, R.A.	Giant Cover Dept., Fort Dunlop.
R. Hodges, Corporal, Royal Corps of Signals	Tyre Sales Division, Birmingham Depot.
H. E. Hopcroft, Lieut.-Colonel, R.A.S.C.	Tyre Sales Division.
W. A. Moens, Commander, R.N.V.R.	Manager, National Sales Division.
G. W. Parsons, Major	Sports Division.
E. Ramsay, Flight-Lieut., R.A.F.	Chief Clerk, Liverpool.
C. W. Salt, Sergeant	Stoke.
I. G. Templer, Lieut., R.N.V.R.	Dunlopillo Division.
S. A. Thomson, Squadron-Leader, R.A.F.	Sports Sales Division.

CIVIL DECORATIONS AND AWARDS

The Most Excellent Order of the British Empire.

Commanders (C.B.E.)

J. P. Anderson	Chief Purchasing Agent.
W. Lemkin	General Manager, Clothing Division.

Officers (O.B.E.)

F. Monk	Employment Manager, Fort Dunlop.
H. Willshaw	Chief Engineer, Rubber Factories.

Members (M.B.E.)

F. Fellowes	Manager, Road Transport Division, Albany Street.
G. Hatton	Balloon Division.
E. Jackson	Experimental Engineer, Rim & Wheel Co., Foleshill.
J. W. Wood	Manager, Cycle & Motor Cycle Manufacturers' Divn.

The George Medal

Miss Betty Quinn	General Stores, Fort Dunlop.

The British Empire Medal (B.E.M.)

Miss L. Bull	Tube Department, Fort Dunlop.
W. J. Cadden	Fort Dunlop.
P. P. McDonnell	Foreman Engineer, India Tyre & Rubber Co., Ltd.
N. F. Powell	Rim & Wheel Co., Foleshill.
W. B. Stokes	Manager, Staff Training, Fort Dunlop.
W. C. Webster	Machine Tool Dept., Fort Dunlop.

Commended for Brave Conduct, Civil Defence

R. Porter	Maintenance Engineer, Birmingham Depot.